

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

REPORT

of the

Study Team on Water Management Research and Training

February/March 1982

Dr. R. Cummings
Chairman, Technical Advisory Committee
Consultative Group on International Agricultural Research

Wageningen, The Netherlands
February 23, 1982

Dear Sir,

I take the pleasure in transmitting you herewith the final draft of the report of the TAC Study Team on Water Management Research and Training. Final draft, not because the Study Team contemplates any substantial changes, but because it appreciates an opportunity to make a final review and introduce minor corrections and amendments if necessary.

As instructed by its Terms of Reference, the Study Team has identified the aspects of training and research activities on irrigation water management which are presently not receiving sufficient attention. Current activities in research and training related to irrigation water management cover an enormous range. From the outset it was recognized that the Study Team could not carry out a comprehensive review. Instead we have concentrated on those institutions and programmes which come closest in their concerns and activities to meeting major needs and covering major gaps in irrigation management.

To fill these gaps the Study Team recommends an international initiative in irrigation management, organized as an international network with a small headquarters. The Study Team has developed its proposal recognizing that improvements on irrigation systems performance, through improved irrigation management, is primarily a national responsibility of each country concerned, requiring a multiplicity of national efforts. It was concluded that outside support to national efforts can best be approached in the fields of research, training and information. If properly implemented such activities should have favourable spin-off effects on improved institutional arrangements, which, as the Study Team noted, are almost universally needed.

In view of a serious time constraint, no full account is given in the report of the discussions the Study Team had with numerous organizations and individuals in a number of countries.

The Study Team also feels that, due to the same time constraint, the report does not cover in sufficient detail the subject of small scale irrigation development. It is however unlikely that this would effect the structure of the proposed effort.

The Study Team, in line with the main thrust of its Terms of Reference, has based its practical proposals within the frame work of the CGIAR.

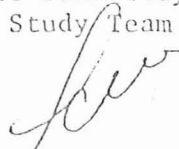
As the report demonstrates the problems of irrigation management require early and adequate action. The CGIAR is an organization with a predominantly agricultural focus. A practical problem therefore to be faced is that irrigation management, a field where multidisciplinary action is mostly needed, is almost universally dominated by the disciplines of engineering, and that whatever is done will need the active support of professionals of that discipline.

The concern of the CGIAR has manifested itself in several inquiries and studies of which this report is the most recent. Appropriate action on an international level to deal with the worldwide deficiencies in the performance of irrigation systems is urgently required.

The Study Team feels that a point has been reached that the CGIAR must decide how to complete the task that it has assumed. Either by supporting the approach herein described or, failing that, it should not drop the matter unless and until some other sponsor has taken on the responsibility.

On behalf of the Study Team I should like to acknowledge our debt of gratitude to the Steering Committee and the TAC Secretariat for their support in carrying out our task.

Yours sincerely,
TAC Study Team on Water Management,



Ir. F.E. Schulze
Teamleader.

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SUMMARY OVERVIEW

The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) has commissioned a 3-person Study Team to report on water management research and training. Its terms of reference include investigating current research and training, identifying gaps and needs, and if appropriate, proposing action. Countries visited include France, Mexico, India, Pakistan, The Philippines, Senegal, Sudan, the United Kingdom, and the U.S.A. Besides national departments and agencies, the Study Team has also consulted representatives of a number of international organizations, private organizations and numerous individuals. The proposals which follow have been developed through these discussions, but are the responsibility of the members of the Study Team alone, serving in their individual capacities.

The importance of irrigation and drainage is indicated by its current scale and associated agricultural production, by projected increases and investment, and by its social significance. Of over 200 million hectares irrigated in the world in 1979, over 70 per cent were in 22 developing countries. The livelihoods of 800-1000 million people in developing countries depend directly on irrigated agriculture. One estimate is that in Asia, investment in new irrigation in the next decade could be of the order of \$75 to \$100 billion. Sri Lanka, India and Mexico are among the countries projecting a doubling of irrigated area by the end of the century. Moreover, irrigation has enormous social significance. With poor management, it can have severe adverse effects, especially through waterlogging, salinity, and the spread of waterborne and water-related diseases. With good management, it can have an immense impact on production and welfare - increasing output, raising incomes, employment and wages, reducing farmers' risks, and restraining migration to overcrowded towns.

The production potential from irrigation is indicated by current yields and efficiencies. Country-wide average yields of paddy (rough rice) in the range from 1.5 - 3.0 tons per harvested hectare reflect rainfed conditions and irrigation with inadequate control, while averages of 5.0 - 6.0 reflect almost complete coverage by irrigation, and advanced water management practices. Irrigation efficiencies, defined as the amount of water delivered to the root zones of the crops as percentage of the amount diverted, have been found to average about 30 per cent only, while well-managed systems have efficiencies of 60 per cent or more and also allow for higher cropping intensities.

Poor performance is often linked with severe deficiencies in irrigation management. These arise from inadequate planning (with narrow objectives, lack of realism, and neglect of non-irrigation aspects), from defects in design (neglecting requirements for flexible operation, on-farm development, and drainage), and especially from deficiencies in operation and maintenance (including farmers' participation, the distribution of water, and financing maintenance).

Good irrigation management requires a multidisciplinary approach, but specialisation leads away from this. In particular, civil engineering training and professional formation reward and value construction and neglect and undervalue the vital activities of operation.

Actions are underway in most countries to remedy the deficiencies but must be greatly strengthened and accelerated if the essential food and social targets which can be achieved through irrigated agriculture are to be met. Many current deficiencies in irrigation management are linked with institutional problems. Institutional changes are a national concern and responsibility but outside support can encourage and catalyse change in conditions favourable to collaboration and where this is acceptable.

Many of the current efforts in research, training, and information for irrigation management have the narrow focus of a single discipline or group of disciplines. There are notable exceptions but these do not, and cannot be expected to, cover all the gaps and needs for research, training and information in their full multidisciplinary and international scope and range of aspects.

Three principles underlie an effective approach to improving irrigation management:

- analysis of whole systems, not just parts;
- multidisciplinary;
- field orientation.

Against this background the Study Team has identified the following areas where an international effort has a key role in supporting national activities as well as activities applicable to all countries rather than to a single country. These are:

- support to and cooperation with national agencies in *action research* in existing irrigation projects;
- *research on practices for irrigation management*, including diagnostic analysis, information systems for monitoring and for system management, water scheduling and delivery, institutional development, and planning and design;
- *training* for professional development;
- *disseminating selected information*, and exchange of experiences in irrigation management;
- concluding studies to determine priorities for more rapid realization of irrigation potentials world wide.

Special attention is proposed to action research as a vehicle, mechanism and spur for other activities. Action research involves diagnostic analysis, identification of interventions, benchmark studies, experimental treatments with monitoring, deriving lessons and solutions, and then extending these more widely. The benefits from good action research in The Philippines, Pakistan and elsewhere have been high, and the methods deserve rapid development and dissemination.

To promote and implement the activities, the Study Team recommends an *International Irrigation Management Institute* organized along the lines of an international network.

The support of the *Institute* to national activities would be both indirect and direct. Indirect support includes an information network, a network to link together existing action research, and workshops and seminars. Direct involvement and support would include variously funded action research, and staff support for national institutes of irrigation management and for regional training. Indirect support would be relatively quick and easy to mount, requiring a minimum of reconnaissance and negotiation, and is strongly recommended. But in itself it is unlikely to achieve the desired impact. Direct support is therefore recommended to countries that request it.

The Study Team proposes that a particular country's involvement can be at a number of different levels, according to whether it participates in an information and/or action research network, whether funds or staff are provided for action research, and whether a national institute or regional training are supported.

Six possible degrees of involvement are shown in the attached chart. For a particular country, the degree of involvement would be largely according to the desires of that country, subject however to negotiation and agreement with the Institute. The degree of involvement could also increase and develop over time.

To carry out its tasks, the Institute would have a small interdisciplinary 'core staff' of some 8-12 professionals plus a field staff which would be built up gradually, depending on agreements reached with a number of participating countries. The core staff would be on a travel status during about a third of their time.

The headquarters of the Institute would consist of offices only without any further physical irrigation facilities, in which respect it differs from the existing centres of the CGIAR system (except for ISNAR, IBPGR, and IFPRI). This is so since action research would be carried out on actual irrigation systems. In practice, the command area covered by action research will often be in the range of, say, 100 to 10,000 hectares.

The Governing Board of the Institute would include: (a) representatives of the principal donor organizations; (b) representatives of leading irrigation developing countries; and (c) professionals in their personal capacity who have had pertinent experience in planning, research, training or operation of irrigation systems. Since the Governing Board might have as many as 20 members, it would not be feasible for it to meet more than once a year. It might therefore be advisable to have a Program Committee of say 6 members made up of persons as under (c). It might be possible for these persons to serve both on the Governing Board and the Program Committee.

The total costs, once in full operation, would amount to 4.5 million US 1982 dollars per annum.

In the Study Team's view the approach proposed will no doubt have to be improved and modified over time. The approach is not without risk, but since the costs of delay are also very high, it is a risk which should be taken.

Increasing levels of involvement	I	II	III	IV	V	VI
Information, seminars, workshops	X	X	X	X	X	X
Action research in network		X	X	X	X	X
Action research actively supported			X	X	X	X
Training partially funded				X	X	X
Regional Training					X	(-)
Support for national irrigation management centre						X
International staff: visits	X	X	X	X	X	X
in residence	-	-	0-2	1-2	1-3	2-4

The number of outposted international staff in each country involved would thus vary from none to four. The number could, however, be raised if funding and agreements were fourth coming.

Definitions

'Irrigation' throughout includes drainage (surface and sub-surface) and may also include flood control, if works to prevent or reduce flood damage are considered essential for realisation of irrigation benefits.

'Irrigation management' is used to reflect the Study Team's emphasis that improved irrigation performance depends on the management not only of water, but of irrigation systems as a whole, including the management of information and controls, of people - both farmers and those who work in irrigation organisations, and of other inputs besides water. As indicated in the terms 'water management' and 'irrigation water management' in the terms of reference, water remains the central, though not exclusive, focus of attention.

'Main system and on-farm system'. In the analysis which follows, the Study Team adopts the normal distinction between the main system and the on-farm system. The main system is the network of canals, branch canals, distributaries and minors down to the outlet, known variously as the chak in parts of India, the mogha in Pakistan, and the meska (farmer's head ditch) in Egypt. The outlet separates the canal system usually controlled by an irrigation organization, and the on-farm system normally controlled by farmers. On smaller systems, often described as communals, the farming community controls the whole system.

Growing seasons and rice-growing schedules

Rabi season: October to April. Cool period crops. Irrigation required because of low rainfall. Important crops: wheat, barley.

Kharif season: April-October. Hot period crops, without irrigation where monsoon rains are adequate. Important crops: Cotton, sorghum, rice.

Aus: Transplanted or broadcast rice, March to mid-June. Often without irrigation, otherwise supplemental.

Aman: Broadcast or transplanted rice, August to mid-November. Deep water rice sometimes much earlier already. Without or with supplemental irrigation only.

Boro: Transplanted rice, December-February, usually fully irrigated.

Acronyms

ARTI	:	Agrarian Research and Training Institute (Colombo)
BRRI	:	Bangladesh Rice Research Institute
CADA	:	Command Area Development Authority (India)
CGIAR	:	Consultative Group on International Agricultural Research
CID	:	Consortium for International Development (a consortium of Western US Universities: Colorado, Utah, Oregon, Washington State, Arizona, Davis California, Riverside California, Texas Tech, Idaho)
CIMMYT	:	Centro Internacional de Mejoramiento de Maiz y Trigo (a CGIAR center, Mexico)
CWC	:	Central Water Commission (India)
DRIP	:	Drainage and Reclamation Institute (Pakistan)
EWUP	:	Egyptian Water Use Project (WRC + CID)
FAO	:	Food and Agriculture Organisation
HYV	:	High Yielding Varieties
IARC	:	International Agricultural Research Center (one of the centers supported by the CGIAR)
IBP	:	Indus Basin Plan (Pakistan)
IBPGR	:	International Bureau for Plant Genetic Resources (a CGIAR agency, Rome)
ICID	:	International Commission on Irrigation and Drainage
IDRC	:	International Development Research Council (Canada)

IFPRI : International Food Policy Research Institute (a CGIAR agency, Washington D.C.)

ILRI : International Institute for Land Reclamation and Improvement (Wageningen)

IRRI : International Rice Research Institute (a CGIAR center, Philippines)

ISNAR : International Service for Support to National Agricultural Research (a CGIAR agency, the Netherlands)

ISP : FAO's International Support Programme for Farm Water Management (Rome)

MOI : Ministry of Irrigation (Egypt)

NIA : National Irrigation Administration (Philippines)

ODA : Overseas Development Agency (UK)

ODI : Overseas Development Institute (UK)

PARC : Pakistan Agriculture Research Council

RAP : Revised Action Programme (Pakistan)

SCARP : Salinity Control and Reclamation Project (Pakistan)

TAC : Technical Advisory Committee (a CGIAR committee, Rome)

UPRIIS : Upper Pampanga River Integrated Irrigation System (Philippines)

USAID : United States Agency for International Development

WAPCOS : Water and Power Consulting Services Ltd., New Delhi

WAPDA : Water and Power Development Authority (Pakistan)

WMSP : Water Management Synthesis Project (a CID activity)

WRC : Water Research Center (Egypt)

Water management has been a subject of discussion by the TAC since its first meeting in January 1971. Several reports prepared by the International Development Research Centre (IDRC) (Ottawa, Canada) were forwarded to and discussed by the TAC in the early seventies.

At the request of the TAC, FAO prepared a review on Research Needs on Water Use and Management in 1976.

A report on research and training needs in the field of water management, prepared for the TAC by an IDRC team of consultants, headed by Sir Charles Pereira, was discussed in the TAC meeting in July 1979. As a number of points in the proposal required further elaboration by the TAC, it was decided to establish a Sub-committee for this purpose. With the help of the Sub-committee the TAC formulated a proposal for the establishment of an International Institute for Water Management Research and Training.

This proposal was forwarded to and discussed by the CGIAR during its International Centres Week and Consultative Group meeting in Manila in October 1980. In the meeting general agreement emerged that irrigation water management deserves high priority for consideration by the Consultative Group, but doubts were expressed as to the concept of the proposal, particularly in respect to its institutional model. Two main reasons were given:

- the problems of irrigation management are mainly location-specific;
- recognizing the need for increased effort, it was felt that this should be met by strengthening national and on-going international activities.

The Consultative Group suggested the formation of a small specialist team to assist the TAC in its consideration of appropriate alternative institutional models.

In its meeting in February/March 1981, the TAC agreed, but asked for more specific guidance from the CGIAR donors, with an indication of their possible commitments. To this end an ad-hoc meeting was held on July 20, 1981 in Washington.

This meeting confirmed the CGIAR interest in irrigation water management, but there was no consensus on the type of organization within the CGIAR system to implement a new international initiative. There was a pressing support for a comparatively modest activity requiring 3-5 million dollars a year.

The draft terms of reference for a study were discussed and amended in line with the consensus that had been reached (see Annex 1).

The study was entrusted to a 3-person Study Team, guided by a TAC Steering Group on Water Management (for composition see Annex 2).

The Study Team started its work on 5 October 1981 at the TAC Secretariat in Rome. A first meeting with the Steering Group took place on 15 and 16 October and a second meeting on 11 and 12 February 1982. In between the Study Team visited a number of countries including Pakistan, India, The Philippines, Sudan, Senegal and Mexico. In addition the Study Team consulted a great number of national and international organizations.

Because of a serious time constraint it is not possible to give a full account of all the discussions and of the very valuable remarks and suggestions which have been made to the Study Team, although these have been taken into account in formulating the proposal presented herein. The responsibility for the proposal remains, however, with the members of the Study Team, serving in their individual capacities.

This chapter discusses the significance of irrigation, and of its current and potential contribution to agricultural production and social justice.

2.1 Objectives

The fundamental objective of irrigation, as of all development, is to improve conditions and quality of life, especially for those who are poorer. On individual irrigation systems this can be achieved through

- enhancing *productivity*, particularly of water;
- improving *equity* of water distribution;
- maintaining long-term *environmental stability*;
- other measures to maximise positive and minimise negative effects on the *quality of life*.

In reviewing the importance and potential of irrigation, the Study Team takes these objectives as central.

2.2 Food Production Needs

The International Food Policy Research Institute (IFPRI)¹ has estimated the 1990 food consumption requirements in 36 low-income countries based on expected population increases and three levels of income growth: zero, low and high. Assuming that present growth rates of production continue, these countries (see Table 2.1) would produce 374 million tons of food but would then have food deficits according to their level of income growth as follows (in million tons):

	Consumption	Deficit
Zero income growth	385	11
Low income growth	430	56
High income growth	448	74

Deficits in individual countries would vary in severity as can be seen from Table 2.1.

The IFPRI report goes on to estimate possible increases in food production from irrigated and from rainfed areas with results as shown in Table 2.1. Two major points emerge. First, even under the low-income-growth projection many countries will remain in deficit. Second, the most populous countries (in Asia and North Africa/Middle East) will have to depend much more on irrigated rather than rainfed agriculture.

2.3 The Social Significance of Irrigation

The benefits of adequate and reliable irrigation water supplies to poor farming families are difficult to overstate. The contrast between high-risk, low-productivity rainfed agriculture and low-risk, high-productivity irrigated agriculture is often dramatic. With well-managed

¹ Peter Oram, Juan Zapata, George Alibaruho, and Shyamal Roy, *Investment and Input Requirements for Accelerating Food Production in Low-Income Countries by 1990*, Research Report 10, International Food Policy Research Institute, Washington, September 1979. Referred to subsequently as IFPRI 1979.

Table 2.1. Production and consumption in 36 low-income countries in metric tons x 1000

	Production			Projected			Deficit		Increase in production to 1990 (a)			
	1990			1990 Consumption								
	1974-76 Actual	Present growth rate	Zero income growth	Low income growth	High income growth	(4) - (2)	(5) - (2)	(7)	From irrigated areas	From rainfed areas	Total (8) + (9)	1990 Food situation
Asia	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Bangladesh	12,932	16,643	22,456	23,412	25,367	10,480	12,435	6,224	3,059	9,283	Deficit	
Eurma	7,044	8,734	8,574	9,084	9,686	2,040	2,642	1,778	3,813	5,591	Surplus	
India	118,726	176,344	169,680	185,103	190,399	66,377	71,673	67,661	14,181	81,842	Surplus	
Indonesia	23,799	37,470	35,215	42,814	44,858	19,015	21,059	10,614	10,518	21,132	High growth	
Nepal	3,082	3,552	4,339	4,376	4,437	1,294	1,355	1,100	1,170	2,270	Surplus	
Pakistan	12,924	27,066	21,086	23,727	24,367	10,803	11,443	8,735	1,085	9,820	Low growth	
Philippines	7,106	12,140	11,981	13,276	13,508	6,170	6,402	2,601	2,653	5,254	No growth	
Sri Lanka	1,407	2,450	3,161	3,534	3,675	6,127	2,268	1,136	591	1,727	Deficit	
Total	187,020	287,219	276,492	305,326	316,297	118,306	129,277	99,849	37,070	136,919		
North Africa/ Middle East												
Afghanistan	4,370	5,081	6,626	6,788	7,106	2,418	2,736	1,987	647	2,634	High growth	
Egypt	7,756	10,928	13,324	13,929	14,102	6,713	6,346	3,404	-	3,404	Deficit	
Sudan	3,741	6,345	4,931	5,456	5,614	1,715	1,873	2,545	2,493	5,038	Surplus	
Total	15,867	22,354	24,881	26,173	26,822	10,306	10,955	7,936	3,140	11,076		
West and East Africa (23 countries)												
Total	53,197	65,259	81,958	96,137	102,437	43,940	50,240	1,710	36,539	38,249		
Latin America												
Bolivia	858	971	1,469	1,677	1,746	819	888	70	665	735	Low growth	
Haiti	746	2,188	1,029	1,073	1,165	327	419	71	317	388	High growth	
Total	1,604	3,159	2,498	2,750	2,911	1,146	1,307	141	982	1,123		
36 country total	256,688	377,991	385,829	430,386	448,467	173,698	191,779	109,636	77,731	187,367	Low Growth	

(a) From proposed investments in irrigated and rainfed agriculture.

Source: IFPRI 1979: 26-29, 86-87.

irrigation come sharp increases in food supplies and income. With more than one crop season a year, the farm family gains food and income at shorter intervals. Risks of food shortage, indebtedness and impoverishment are reduced. There is less need to migrate seasonally or to suffer the disruption, family separation, and obstacles to children's education which migration often entails. And reliable irrigation opens up opportunities to benefit from the synergistic effects of new agricultural technology.

For those who are landless, or who live partly by labouring, reliable irrigation brings employment and often higher wages. New irrigation schemes often entail land redistribution and settlement of landless families. The visible prosperity of many of the areas which receive reliable irrigation demonstrates the opportunities for agricultural-related and non-agricultural employment.

The improved livelihoods and employment generation provided by well-managed irrigation discourage urban migration and promote migration into the irrigated areas, both seasonal and for lasting settlement. Counter migration can also be attracted from cities. Well-managed irrigation thus helps not only the rural poor, but also the poor in urban areas by reducing the pressure on urban employment opportunities and amenities.

Adverse effects also occur, especially where irrigation systems are poorly managed. Livelihoods may be impaired and whole areas even impoverished through waterlogging and salinity, forcing outmigration and pressure on employment and wages elsewhere. Sometimes the additional work generated by irrigation may place excessive burdens on family members. For example, women may have to work harder in less healthy conditions. Poorly planned or managed irrigation schemes can have adverse health effects through the breeding of vectors for diseases such as schistosomiasis and malaria. These can be reduced through good planning and good management, and provision can be made for non-agricultural benefits from irrigation, such as washing and other domestic uses.

2.4 The Scale and Significance of Irrigation and Production

For national economies, the significance of production from irrigation includes food security from larger and more reliable crop production; relative ease in developing and maintaining buffer stocks of food;

savings of foreign exchange otherwise required for food and fibre imports; foreign exchange earnings from irrigation-based exports; and general support for economic diversification and development.

The scale of irrigation, according to Table 2.2 (from 1980 FAO Production Yearbook), was 206 million ha worldwide in 1979 representing 15 per cent of the area cultivated. This percentage is higher if areas with drainage and flood protection facilities but no irrigation are included.¹

The major relative importance of irrigation to developing countries is indicated by Table 2.2. No less than 152 million ha (74 per cent of the 206 million ha) are located in developing countries, including China.

Grouping the developing countries by region and according to extent of area, those with 1 million or more hectares are shown in Table 2.3.

Some statistics for the effect of irrigation on production in several leading countries of South Asia are given in Table 2.4. For South Asia as a whole, over 2/3 of the production increase in cereal production in 1962-1980 has been due to irrigation.

¹ According to R. Darves-Bornoz, President, ICID, this may amount to 150 million ha, see *Journal of Hydraulic Research* 19 (1981) No. 4.

Table 2.2. Irrigation in the World

05/23/81

	AGRIC AREA				1000HA SUP AGRICOLA			
	1969-71	1973	1976	1979	1969-71	1973	1976	1979
WORLD	170168	181445	193763	206514				
AFRICA	7034	7449	7775	8188				
ALGERIA	273	300F	313	336				
BENIN	10F	13F	16F	19F				
BOTSWANA	2	1	1*	2F				
BURUNDI	5	5	5*	5*				
CAMEROON	6F	7F	8F	8				
CAPE VERDE	2	2	2*	2*				
CHAD	1	1	1	3F				
EGYPT	2843	2855	2814F	2850F				
ETHIOPIA	55	55F	55F	55F				
GAMBIA	20F	25F	25F	30F				
GHANA	15	18F	20F	22F				
GUINEA	5F	5F	6	10F				
IVORY COAST	20	23*	25F	26F				
KENYA	29F	38	42	46F				
LIBERIA	1	2*	2	3F				
LIBYA	131	130F	135F	140F				
MADAGASCAR	337F	390F	430F	460F				
MALAWI	4	6F	8F	10F				
MALI	63	80F	90F	100F				
MAURITANIA	4F	6F	8	8F				
MAURITIUS	15	15	15*	15*				
MOZAMBIQUE	340F	385F	445F	500				
MOZAMBIQUE	61F	65F	68F	68F				
NAMIBIA	6F	6F	7F	8F				
NIGER	19F	22F	24	36F				
NIGERIA	15	15*	20F	25F				
REUNION	6	7	7	8F				
RWANDA	1	1	1	2F				
SENEGAL	112	140F	165F	180F				
SIERRA LEONE	3F	3F	4F	6F				
SOMALIA	163	162*	165F	165F				
SOUTH AFRICA	999F	1017	1017*	1020F				
SUDAN	1250F	1407	1550F	1700F				
SWAZILAND	24	26*	26F	30F				
TANZANIA	46	50F	55F	62F				
TOGO	3	3*	3*	8F				
TUNISIA	90	105F	130F	140F				
UGANDA	4	4	4	5F				
UPPER VOLTA		1*	2*	5F				
ZAIRE			2F	5				
ZAMBIA	3	3F	4F	5F				
ZIMBABWE	47	50F	55F	60F				
N C AMERICA	20989	22169	23234	23893				
BELIZE	1	1	2*	2F				
CANADA	420	440F	480F	500F				
COSTA RICA	26*	26	26*	26*				
CUBA	453F	510F	650F	900				
DOMINICAN RP	125F	130F	135F	145F				
EL SALVADOR	20*	33	30	102				
GUATEMALA	2*	2	1	2F				
HAITI	57	60*	62F	66F				
HONDURAS	60	70	70*	70*				
JAMAICA	69	75F	80F	80F				
MARTINIQUE	26*	30F	32F	32F				
MEXICO	1	1	2	4				
NICARAGUA	3611	4127	4816	5100F				
PANAMA	40	55F	70	70F				
PUERTO RICO	20F	20F	23F	28F				
SAINT LUCIA	39	39	39	39*				
SAINT VINCENT	1	1	1*	1*				
TRINIDAD TOB	1	1	1	1*				
USA	15	10F	20F	20F				
	16002	16510F	16694F	16697				
SOUTH AMERIC	5682	6228	6755	7233				
ARGENTINA	1280	1380F	1477	1560F				
BOLIVIA	80	100	120F	125F				
BRAZIL	815	1100F	1400F	1700F				
CHILE	1180F	1238	1245F	1252*				
COLOMBIA	250F	265F	285F	305F				
ECUADOR	468	480F	510F	520F				
GUYANA	115	120F	122F	122F				
PARAGUAY	43F	50	55F	55F				
PERU	1095	1120F	1150F	1180F				
SURINAME	27	30F	30F	34F				
URUGUAY	49	55F	58F	70F				
VENEZUELA	274*	290F	303	310F				
ASIA	113129	119189	125941	134415				
AFGHANISTAN	2340F	2400	2520F	2510*				
AFGHANISTAN	1	1	1*	1*				
BANGLADESH	1054	1299	1218	1520F				
BURMA	842	890	985	1044				
CHINA	42000H	43500F	45600F	49200F				
CYPRUS	97	94	94*	94*				
HONG KONG	8*	7	6	4				
INDIA	30183	31840	34490	39090				
INDONESIA	4371	4700F	4900	5360F				
IRAN	5184F	5500F	5840	5900F				
IRAQ	1477F	1530F	1600F	1730F				
ISRAEL	169	170	187	189				
JAPAN	3312F	3295F	3276	3261				
JORDAN	61	67F	80F	85F				
KAMPUCHEA DM	89	89*	89F	89F				
KOREA DPR	500F	700F	1000*	1050F				
KOREA REP	993F	1020F	1082	1150F				
KUWAIT	1	1	1	1*				
LAO	18	30F	50F	78F				
LEBANON	70	85F	85F	85F				
MALAYSIA	243	298	330F	360F				
MONGOLIA	10F	18F	25F	32F				
NEPAL	116	117	190F	220F				
PAKISTAN	12904	13634	13830	14450F				
PHILIPPINES	830	980F	1154	1269				
SAUDI ARABIA	340F	370F	390F	395F				
SRI LANKA	436	427	483F	550F				
SYRIA	491	619	547	539				
THAILAND	1965	2300F	2448	2630F				
TURKEY	1783	1950F	2000F	2050F				
U A EMIRATES	5	5	5*	5*				
VIET NAM	980F	980F	1150F	1684				
YEMEN AR	210F	225F	230	243				
YEMEN DEM	40F	48F	55F	67F				
EUROPE	10718	12058	13118	14128				
ALBANIA	267	309*	350F	370F				
AUSTRIA	4	4*	4*	4*				
BELGIUM-LUX	1*	1*	1*	1*				
BULGARIA	998	1070	1147	1185				
CZECHOSLOVAK	84	90F	94F	98F				
DENMARK	92F	140F	201	372				
FINLAND	16	30F	45	60F				
FRANCE	750F	780F	819	860F				
GERMAN DR	142F	155F	160F	165F				
GERMANY FR	284	296F	310	314F				
GREECE	757	856	939	955F				
HUNGARY	178	311	320	352				
ITALY	2560	2650F	2750F	2840F				
MALTA	1	1	1	1				
NETHERLANDS	210F	250F	266	275F				
NORWAY	4F	4F	4	8				
POLAND	218	208	198	114				
PORTUGAL	622	625F	628F	630F				
ROMANIA	773	1255	1729	2253				
SPAIN	2476	2736	2854	2997				
SWEDEN	33	45F	58*	60F				
SWITZERLAND	25	25F	25F	25*				
UK	89	84	91	135				
YUGOSLAVIA	133	163	124	154				
OCEANIA	1584	1608	1640	1657				
AUSTRALIA	1474	1470F	1475	1490F				
FIJI	1*	1*	1*	1*				
NEW ZEALAND	109	135	164	166				
USSR	11033	12746	15300	17000				
DEV. PED N E	30542	31697	32413	33014				
N AMERICA	16422	16950	17174	17197				
N EUROPE	8058	8660	9120	9691				
OCEANIA	1583	1605	1639	1656				
OTH DEV. PED	4479	4482	4480	4470				
DEV. PING N E	82354	88317	94188	100008				
AFRICA	1811	2040	2259	2478				
LAT AMERICA	10248	11447	12815	13929				
NEAR EAST	16324	17287	17947	18085				
FAE EAST	53970	57542	61166	67715				
OTH DEV. PING	1	1	1	1				
CENTR PLANN	57272	61431	67162	73492				
ASIAN CPE	43579	45287	47864	52055				
E EUR+USSR	13693	16144	19298	21437				
DEV. PED ALL	44235	47841	51711	54451				
DEV. PING ALL	125933	133604	142052	152042				
				154583				

See Afghanistan
Stan.* = unofficial figure
F = FAO estimate1980 FAO Production Yearbook,
vol. 34, Rome, 1981.
table 2, page 57

Table 2.3. Developing countries with over 1 million hectares irrigated

<u>East Asia</u>	
China	49.2
Vietnam	1.7
Korea Republic	1.0
Korea DPR	1.0
<u>South Asia</u>	
India	39.1
Pakistan	14.5
Bangladesh	1.5
<u>Southeast Asia</u>	
Indonesia	5.4
Thailand	2.6
Philippines	1.3
Burma	1.0
<u>Middle East and North Africa</u>	
Iran	5.9
Egypt	2.9
Afghanistan	2.5
Turkey	2.1
Iraq	1.7
Sudan	1.7
<u>Latin America</u>	
Mexico	5.1
Brazil	1.7
Argentina	1.6
Chile	1.3
Peru	1.2

'Data on irrigation relate to areas purposely provided with water, including land flooded by river water for crop production or pasture improvement, whether this area is irrigated several times or only once during the year stated.' FAO Production Yearbook, 1980.

Table 2.4. The Contribution of Irrigated Lands to the Production of Rice and Wheat in South Asia

	% of Cultivated Area (1979)	% of Production (1978-1980)	% of Production Increase (1961-1980)
	(- - - - - p e r c e n t - - - - -)		
<u>Rice</u>			
Bangladesh	12	22	66
Burma	13	18	29
India	42	55	67
Pakistan	98	99	99
Sri Lanka	62	70	74
South Asia	36	46	62
<u>Wheat</u>			
Bangladesh	54	72	75
India	65	81	93
Pakistan	77	87	91
South Asia	67	82	91

Source: World Bank Staff, 1982

2.5 The Potential for Future Production

The IFPRI 1979 study, besides the orders of magnitude for increases in food production from 1975 to 1990, estimated the investment required in 36 low-income countries. Projected increases in production from irrigation (both new irrigation, and improvement of old irrigation) were contrasted with those from rainfed agriculture. Irrigation would be responsible for 73 per cent of the increased production of 137 million tons in Asia, 71 per cent of the increased production of 11 million tons in North Africa and the Middle East, but only 4 per cent of the increased production of 38 million tons in East and West Africa. The long gestation period before production can be achieved from new schemes and shortages of trained manpower are two reasons why countries in East and West Africa (except Sudan) cannot look to irrigated agriculture as a major means in the near future to meet a substantial proportion of their food and fibre needs. A large potential for irrigation exists in the

East and West African region, but for the next two decades, almost all its increased agricultural production will have to come from rainfed areas.

Requirements and proposals for future investment in new irrigation and the rehabilitation of existing irrigation are on a scale which supports and confirms the orders of magnitude of the IFPRI scenario. The capital costs of additional production were estimated by IFPRI in 1975 dollars as \$ 52 billion for water resource development, and \$ 47 billion for other investment¹ to support and complement both irrigated and rainfed agriculture. A 1978 report of the Trilateral North-South Food Task Force to the Trilateral Commission proposed cumulative irrigation investment of \$52.6 billion (1975 prices) over the period 1978-1993, for thirteen Asian countries² to meet estimated annual growth in rice consumption of 3.4 percent.

The projected irrigation development in FAO's normative scenario for production growth in *Agriculture: Toward 2000* implies a cumulative investment, 1980-90, in the Far East (including the 13 countries in the Trilateral report plus Japan and North and South Korea) of around \$60 - 65 billion (1975 prices). These aggregate projections are in at least rough agreement with IFPRI's (1979) on the order of magnitude of investment in irrigation required to meet projected growth in food consumption. The sheer size of the investment involved, and the high proportion of production growth projected to come from irrigation development, indicate the critical importance of irrigation development, and of the high targets which are being set.

The scale of proposed investments and of the potential benefits from them can further be illustrated from countries visited by the Study Team or with which members of the Study Team have familiarity (for more detail see Annex 3).

¹ The breakdown (IFPRI 1979:139) was road improvements \$ 9.9 billion; rural electrification 7.2; disease eradication 1.6; fertilizer manufacture 9.1; seed industries 0.3; mechanisation 4.2; animal draft 0.9; storage and drying 4.5; research 1.6; and extension 1.4.

² U. Colombo, D.G. Johnson, and T. Shishido, *Reducing Malnutrition in Developing Countries: Increasing Rice Production in South and Southeast*, Report of the Trilateral North-South Food Task Force to the Trilateral Commission, New York, Tokyo, Paris, 1977, The countries were Asia, Bangladesh, Burma, Cambodia, India, Indonesia, Laos, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam.

India already has some 60 million ha 'commanded' by irrigation, and of this some 45 million ha are irrigated (1981). Although yields in irrigated conditions are low by world standards (only about 1.7 tons per ha for foodgrains, combined with a surprisingly low degree of double cropping), irrigation provides 81% of current wheat production and 55% of current rice production (Table 2.4). India plans to increase overall production of food grains from 120 million to 150 million tons during the current Sixth Plan (1980-1985), and towards this is investing about \$ 3 billion per annum in irrigation works. Of this, 90 per cent is for new irrigation projects, and 10 per cent for rehabilitation. The area projected to come under new irrigation during the Plan period is 14 million ha. By the end of the century, India plans to have doubled its irrigated area, to its full potential of some 113 million ha. Provided that its irrigation systems are well managed, India should become established as a stable food-surplus country.

In *Pakistan*, of the cropped area of 20 million ha, 14 million are irrigated accounting for 90% of production. The Indus irrigation system, the largest in the world, commands 12 million ha but, as in India, yields, the extent of double cropping and water-use efficiency are low. During the current Five-Year Plan (1978-83) the water subsector has been allocated \$ 1.7 billion but much larger sums will be required in future Five-Year Plans. Even then, according to IFPRI projections (see Table 2.1), it will be difficult to meet food-production requirements by 1990.

In *Egypt*, 2.4 million ha of so-called 'Old Lands' have converted to year-round irrigation since completion of the High Dam in 1969. Resulting rising watertables are being controlled through a massive drainage program. Much more work remains to be done while yields and multiple cropping must be increased to keep up with population growth and loss of land to urbanization. Reclamation of additional lands, generally of marginal quality, followed by irrigation, is planned to reach about a million ha by the Year 2000. The rate of expenditure envisaged for rehabilitation of the Old Lands and reclamation of new lands is about \$ 500 million per year.

Mexico, like India, plans to double its irrigated area by the end of the century, from 5.5 million ha to 11 million ha, to rehabilitate and drain about a fourth of the area presently irrigated, to increase water-use

efficiency mainly through land-levelling and to begin development of its extensive tropical-humid zone (about 4 million ha) mainly through drainage and flood control. To achieve this Mexico plans to spend \$ 3 billion per year during 1982-1990, and \$ 4 billion per year during 1990-2000 (1980 dollars).

Bangladesh has a subtropical humid climate with a pronounced dry season. Its irrigated area, now about 1.5 million ha, is expected to triple by the year 2000.¹ Owing to soils and topography (most of the country is in the Brahmaputra-Ganges deltaic plain), the works required are a combination of flood embankments, drainage works, low-lift irrigation pumps and tubewells. Given the very high population density, the high fertility of the soils and the low yields and cropping intensities now prevailing, accelerated development of irrigation, drainage and flood control in Bangladesh are imperative. Recent successes, although of a limited extent thus far, substantiate the need for further investments for these ends. Note from Table 2.1 that, even with accelerated development, Bangladesh would remain a food-deficit country.

Although the foregoing figures should be treated with caution, what they do establish is that in countries with large concentrations of poor people, especially in South and Southeast Asia and parts of the Middle East and North Africa, massive investments are projected in irrigation. Other countries that are not so poor, like Mexico, but which have large pockets of poverty and are experiencing very rapid urbanization, are also planning very large investments in irrigation.

Some of the planned investments are for rehabilitation, but the bulk is for new irrigation, with some countries planning to double their irrigated area in the next twenty years. In several countries, these are the central agricultural development thrusts and are seen as the most feasible major investments in forms of agricultural production which will benefit small farmers and generate additional agriculturally based livelihoods. The potential benefits are vast; but to what extent they can be realised depends on the level of irrigation management and performance that can be achieved.

¹ IFPRI projects this as happening by the year 1990. See IFPRI 1979 p. 75.

3.1 Gauging Performance

As explained in Chapter 2, irrigation is already, in many countries, the leading factor in agricultural production and in achievement of social goals. But are irrigation systems performing as well as they should? If not, to what extent are they failing to meet targets and what are the prospects of meeting the future very ambitious targets described in Chapter 2?

To provide preliminary answers to these questions, the Study Team visited several countries (see Chapter 1) and drew on knowledge on these and other countries through previous visits and studies. The results of this work are presented in Annex 3.

From Annex 3 it is clear that existing irrigation systems, although of vital importance, are in general performing poorly, whether measured in terms of planned targets or production potentials created by the physical works in the systems. In many systems, the 'area irrigated' is much less than the 'area commanded'. Intensities of irrigation are low. Maldistribution between headreaches and tailends is almost universal. Water delivered corresponds badly in quantity and timing with changing crop water requirements. Environmental problems, especially waterlogging and salinity, are cause for growing concern. With respect to the massive investments proposed for new systems, there is danger that unless irrigation management is improved, these negative aspects will become more serious.

These common defects in system operation and water delivery are reflected in poor achievement of the objectives of irrigation (see para 2.1) as follows:

1. *Productivity.* The productivity of irrigation systems is low for many reasons, including water wastage, high transmission losses, small areas irrigated, inadequate, unreliable and untimely water deliveries and farmers' consequently cautious choices of crops and practices. The average yield of food crops on irrigated land in India is only 1.7 tons per hectare, compared with close to 6 tons per hectare in Japan. Water efficiencies average almost 70% in Taiwan, but only 25-40% in India (Annex 3), and for South and Southeast Asia generally are in the range of only 20-50%.
2. *Equity.* Sharp inequity is common between headreach and tailend farmers. For inequitable water distribution in Egypt see Annex 3. Recent research shows the gradients of deprivation to be steep. A study of the 180,000 ha Mahanadi Reservoir Project in India has found that yields declined from 1935 kg/ha cereal at the head down to only 350 at the tail.¹ Research in Sri Lanka has revealed that tailenders suffer multiple deprivations compared with those in the headreaches, receiving less water, less reliably and in less timely fashion, and having lower yields, lower returns to labour, lower incomes, less access to services and less influence.
3. *Environmental stability.* Productivity and equity are both affected by environmental problems, especially waterlogging and salinity. These are very serious problems in countries such as Pakistan, India, Iraq, Egypt and Peru.
4. *Quality of life.* Quality of life is adversely affected by low productivity, inequitable distribution of water and waterlogging and salinity. In addition, rather little attention has been paid to the effects of irrigation on women and children. Health, nutritional and family impacts of irrigation need to be better understood. In particular, some adverse health effects, especially malaria and schistosomiasis, are often much worse than they need be. It is imperative that these aspects receive greater attention in the planning, design and management of irrigation projects.

¹ Data from Water and Power Consultancy Services (India) Ltd., New Delhi.

3.2 Current Deficiencies

Current deficiencies can be grouped in various ways. In the following discussion, which is based largely on the findings in Annex 3 the deficiencies are grouped according to:

- physical works,
- farming systems,
- system operation,
- institutional arrangements.

From Annex 3 it is seen that in general:

- a. main systems do not deliver water in an adequate amount or in a timely manner;
- b. the on-farm system of water delivery suffers in the same manner;
- c. water delivery is moreover inequitable since tailenders and often the smaller farmers do not receive their fair share of water;
- d. on-farm land preparation is faulty causing wastage of water and inhibited plant growth;
- e. in some systems, rising watertables are causing waterlogging and salinity.

Physical works

With regard to the main system, physical deficiencies include:

- insufficient control structures and measuring devices;
- absence of canal lining and automation (to the extent practicable and if properly phased);
- insufficient communications (roads and telecommunications);
- inadequate or poorly maintained drains.

The on-farm system needs:

- measuring devices and better outlet structures from the main system;
- better field channels downstream of the outlet structures;
- better division boxes serving individual farmers or small groups of farmers;
- better land preparation (land shaping and land levelling).

In many (but not all) cases, physical improvements in the main system must either precede or at least be concurrent with improvements in on-farm water-delivery systems so that the latter can function properly.

Farming systems

Agricultural systems interlock with irrigation water supply. With inadequate, unreliable and untimely water supplies, and with water-logging or saline conditions, farmers have low incentives for on-farm development, for the maintenance of irrigation ditches and drains, or for the adoption of high yielding crops and varieties, fertilizers and improved practices. Irrigation water is only one input: other factors - labour, farm roads, fertilizers, pesticides, credit, marketing, prices - influence farmers' practices and the productivity of irrigated agriculture. A lack of farming system research has allowed the significance of irrigation water as a leading input to be under-recognized, when in practice it is usually a precondition for the adoption and use of other inputs and for on-farm investment.

System operation

Operational deficiencies on main systems include:

- permissive misallocation of water with excesses to headreaches and shortages at tailends;
- water wastage especially at night;
- slow or non-existent responses to rainfall;
- distribution according to broad rules of thumb without close attention to crop irrigation water requirements;
- inadequate phasing and zoning of cropping patterns and planting times;
- lack of monitoring facilities and procedures to enable managers to know how their systems are performing;
- inadequate maintenance;
- unwillingness or inability to deliver water to outlets in predetermined quantities and at predetermined times;
- lack of two-way communication with farmers.

Operational deficiencies at the on-farm level include:

- absence of organized rotation;
- lack of maintenance of channels and drains;
- lack of synchronisation and phasing of crops to fit water availability.

Institutional arrangements

With respect to main systems, a gulf is common between Ministries or Departments of Irrigation, usually controlling the distribution of water on main systems, and Ministries or Departments of Agriculture, usually engaged below the outlet at the on-farm level. Irrigation engineers are trained in design and construction but not usually in operation or agriculture. Careers in design and construction are considered more glamorous and prestigious while irrigation-system management is regarded as a second or third best. Transfers of staff are frequent. Incentives for good performance are weak or non-existent. Funds and other resources for maintenance are inadequate. Those who manage irrigation systems are subject to local pressures to misallocate water.

At the on-farm level, farmers' organizations often do not exist, or are weak. Rotations are unnecessary in headreaches where water is abundant, and difficult to organize in tailreaches where the water supply is unreliable. Communications are poor between farmers' groups and the irrigation management staff who control water distribution on the main system.

3.3 Potentials for Better Management

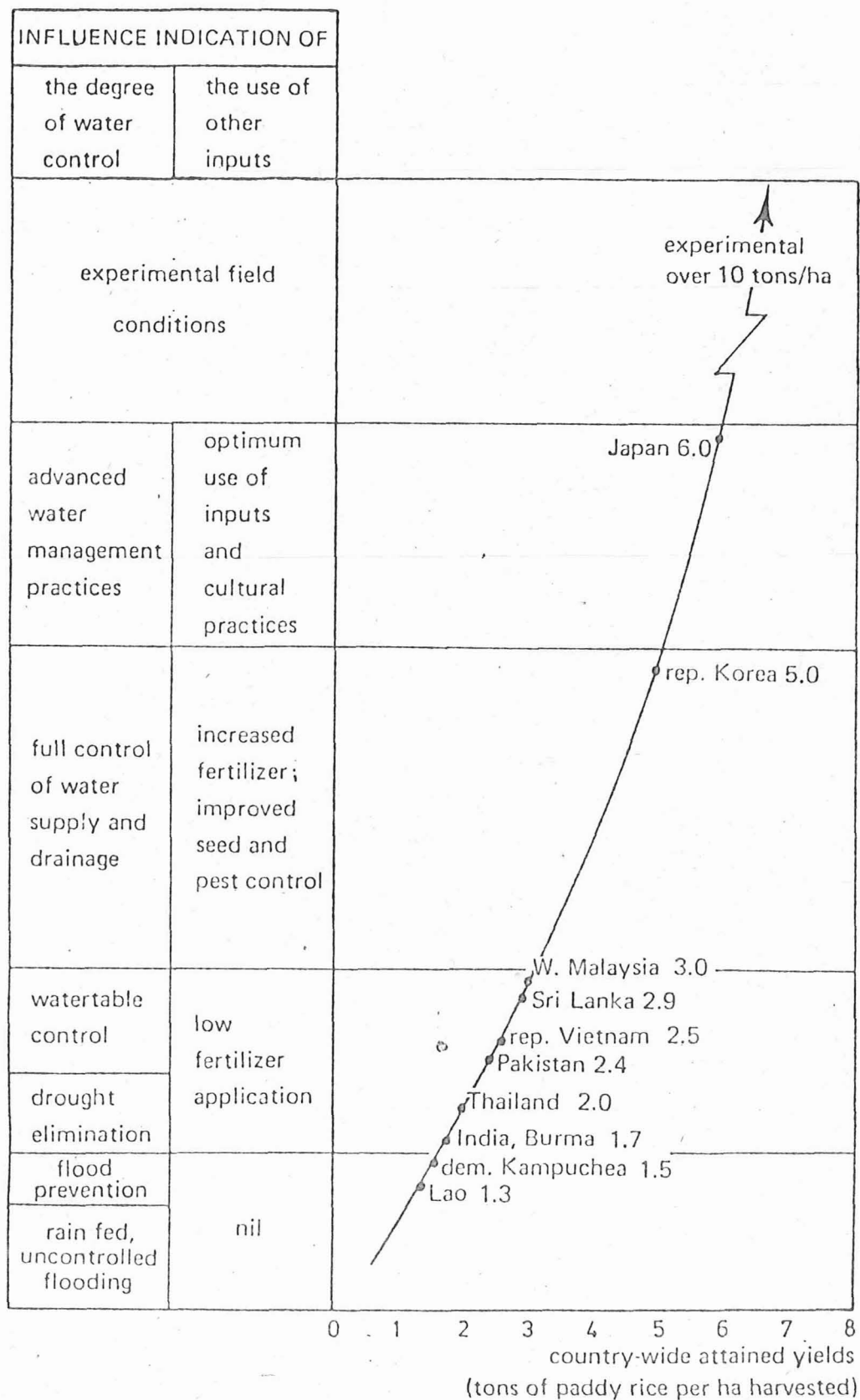
If the more significant of these deficiencies can be moderated or overcome, the gains will be large:

As shown in Figure 3.1, country-wide attained yields of paddy (rough) rice in a number of developing countries vary between 1.5 and 3.0 tons per harvested hectare, reflecting a proportion of rainfed conditions and irrigation with inadequate control. Yields obtained under full control of water supply and drainage and advanced water management practices show country-wide figures of 5.0 - 6.0 tons per harvested hectare, while yields under experimental conditions even exceed 10 tons. These figures suggest that a great potential exists for raising production through extending irrigation and good irrigation management and proper use of other inputs.

A survey carried out by ICID and ILRI¹ on 91 irrigation projects all over the world, has indicated that irrigation efficiencies are very low and on the average, although with considerable variation, of the order

¹ M.G. Bos and J. Nugteren, *On Irrigation Efficiencies*, International Institute for Land Reclamation and Improvement, Publication 19, 1978.

Fig. 3.1. Country-wide paddy production levels in some selected countries



Ref: FAO (1979)
The On-Farm Use of Water.
Committee on Agriculture

of only 30%. The efficiencies as described in Annex 3 for India and Pakistan confirm these findings. In India only about 25% to 40% of the water diverted is delivered to the crop root zones (Annex 3 para 3). Studies carried out in Pakistan (Annex 3 para 47) also show overall irrigation efficiencies of the order of only 30%.

Comparison of these figures with well-managed irrigation projects having irrigation efficiencies of 50-60% shows that there is a considerable potential for improvement at relatively low costs. From the Revised Action Programme (RAP) study in Pakistan it was for instance concluded that the cost per acre-foot of water saved through watercourse improvement is only one fourth of the cost of developing new water supplies (Annex 3, para 56).

Improvement in irrigation efficiencies opens the possibility of increasing the irrigated area and extending irrigation to farmers who otherwise would not receive water. On many systems there is a potential for increasing the production by stretching the water over a larger area to benefit a larger population. An increase in cropping intensities is another opportunity offered by the improvement of irrigation efficiencies.

According to a comparative study of the management and organization of irrigation projects, commissioned by the World Bank,¹ irrigation management reform involving the redistribution of water should, in the predominantly rice growing areas of Asia, be capable of generating average production increases of at least 20 per cent; on this very conservative assumption, which contained a large discount for the effects of replication, this would mean an increase of rice production of about 30 million tons of paddy or 20 million tons of rice.

Unlike the green revolution, criticized for helping larger farmers but doing little or nothing for the poor, water redistribution can achieve both production and equity at the same time. The opportunity is to find ways to transform the family economies of tens of millions of people - small and poor farmers, labourers, and others - who depend for their livelihoods on unreliable and unproductive tailend agriculture.

¹ Anthony Bottrall, Comparative Study of the Management and Organization of Irrigation Projects, World Bank Staff Working Paper No. 458, May 1981.

Competition for scarce water is increasing between nations, between regions within nations, and between agricultural, urban, and industrial demands. These conflicts should be moderated to the extent that more can be produced with the same or less water (see Annex 3, para 116 for instance).

Finally, improved performance on existing irrigation systems is increasingly required to justify the very large investments sought, and needed, in new irrigation projects. The cheaper and easier irrigation sites have already been developed. Those that are now appraised for funding are less and less attractive, especially at current levels of performance. There is already concern among funding agencies at the recurrent shortfalls of performance. In the harsher investment climate of the 1980s, funding for new projects will become difficult unless the performance of existing irrigation systems improves. Some suboptimal projects will go ahead for political and other reasons. But generally, existing systems will have to perform better to justify the tens of billions of dollars projected for future investment. And that new investment is needed if production and livelihoods are to keep pace with increases in population and if current poverty is to be substantially reduced.

4.1 The Range of Current Efforts

Removal of the deficiencies summarized in Section 3.2 (Current Deficiencies) involves a multiplicity of current efforts. These are described for several key countries in Annex 3. Owing to local variations and the wide range of activities involved it is difficult to present a brief summary except for a general observation that current efforts, although some are in the right direction, are seriously inadequate and need much strengthening and speeding up.

As to deficiencies in physical works described in Section 3.2, current efforts with respect to on-farm development programmes in India, Pakistan, Egypt, The Philippines and elsewhere are on limited canal commands. These activities need to be stepped up in these countries as well as initiated in countries where they do not exist. With respect to rehabilitation and improvement of existing main systems the analyses, studies and project planning for physical works needed are not generally receiving adequate attention since most irrigation agencies are more interested in construction of new systems.

The dangerous effects of waterlogging and salinity are widely recognized and important efforts in planning and implementation are underway to deal with the problem. These efforts are not however sufficiently coordinated at a national level for many large systems. For example, the combined effects of on-farm water management, major drainage improvements, and conjunctive use (of groundwater and surface water) are not being adequately integrated. As to farming systems and agricultural

inputs and practices, a major on-going effort has been the establishment in India of Command Area Development Authorities (CADAs).

As described in more detail in Annex 3, the CADAs have been mainly concerned with physical improvements of on-farm systems and organization of farmers for better operation of the systems. The CADAs have had only limited success, partly because of institutional weaknesses but also because not enough attention has been given to development of appropriate farming systems -- a research topic needing attention as mentioned in Section 3.2. Pakistan has also experimented with arrangements similar to the CADAs and is planning further experiments and pilot programs. A prevailing difficulty in both countries is, again, lack of adequate water delivery from the main system to the on-farm system, without which in most cases farmers will not risk investments in better agricultural practices.

Farmers' involvement and use of agricultural inputs depend on better and more reliable water delivery, and many other factors. Increasing the interest of the farmer means farmers' participation in all stages of a project (planning, design, construction and operation). The decisive role of the farmer in the performance of irrigation systems and the need for farmers' participation, are well known and generally accepted, at least in theory. In practice the main efforts on these lines have been in some small-scale projects. Not much has been done so far for farmers' participation in the management of larger systems.

In most countries efforts to correct deficiencies in the operation of main systems are at best scattered. There are, however, some encouraging examples. In Andhra Pradesh in India simple systematic rotations and tighter control of water distribution are reported to have led to sharp improvements in performance. Main system management has for some years received attention in The Philippines. These and other usually isolated cases serve, however, to emphasize the extent to which main system water distribution is still neglected.

As is evident from the foregoing discussion, many of the inadequacies in current efforts to eliminate deficiencies can be traced to the weak institutional arrangements described in Section 3.2. Improvements in these arrangements are taking place in several countries, in some at an

acceptable rate and in others too slowly. Since improvements of this nature must occur from within, the Study Team feels that outside intervention should concentrate for the time being on approaches about which local agencies are receptive. These are in the fields of research, training and information, as discussed in the rest of this chapter. Research, training and information activities if properly implemented should have favourable spin-off effects on institutional arrangements. Actions in these fields should moreover be planned taking into account efforts by international financing agencies, particularly those aimed at improvement of institutional arrangements in connection with projects sponsored by such agencies.

Current activities in research, training and information related to irrigation management cover an enormous range. From the outset, it was recognized that the Study Team should not carry out a comprehensive review. Instead we have concentrated on those institutions and programs which come closest in their concerns and activities to meeting major needs and covering major gaps in irrigation management.

4.2 Research

Much current research is *component research* which follows conventional disciplinary lines. Valuable as its contributions have been and will continue to be, these are not a primary concern for the Study Team. Component research which studies one or a few aspects of an irrigation system in relative isolation - whether in engineering, soils science, hydraulics, agronomy, agricultural engineering, or one of the social sciences - is best undertaken by specialized individuals or teams; and specialized institutions for such work exist in many countries, usually organized along disciplinary lines. We are more concerned with

- a. research which can confront the whole system, including its physical, agricultural, institutional and operational dimensions, and the linkages between these; and
- b. research which can illuminate significant gaps in knowledge and understanding which can lead to improvements in management performance.

There is little research which analyses whole systems. Some consultants' reports purport to do so, but are usually weak on the institutional and

fairly recent, and have been carried out by Indian administrators (Syed Hashim Ali, T.K. Jayaraman and others), the Agrarian Research and Training Institute, Colombo, the Asian Institute of Management, Manila, the Institute of Development Studies, Sussex, the Overseas Development Institute, London, Cornell University, and some other individuals and institutions. Despite these efforts, major gaps remain in the understanding of irrigation systems as wholes, and especially their human management aspects.

In countries with large irrigation systems, such as India, Pakistan, Egypt and Mexico, numerous research projects of various kinds are under-way or planned (see description in Annex 3). Because of the many agencies involved there is duplication or lack of coordination of efforts. This situation points to the need at the national level for guidance, control and monitoring of research concerning irrigation management, and the possibility of international assistance in establishing this.

Action research is a recent development in irrigation management. Examples include (see Annex 4) the Mona Project in Pakistan; work of IRRI and the National Irrigation Administration (NIA) in The Philippines; also in The Philippines NIA's programme on communal irrigation systems; the Agrarian Research and Training Institute and Cornell University Project on Gal Oya in Sri Lanka; the Egyptian Water Use Project; and several projects in India.

Within the broad term 'action research' there are various approaches, but all share a diagnosis to determine interventions, the introduction of the interventions, and then monitoring their effects. In all cases, the interventions are live ones on an existing system. In the view of the Study Team, action research, though scattered and occurring on far too small a scale, is a promising practical approach to identifying and overcoming many of the problems of irrigation management.

4.3 Training

In assessing the coverage of training courses in irrigation management, the Study Team has relied on its previous knowledge, on expert opinion, on secondary sources and on visits to training institutes in France,

India, Mexico, Pakistan, The Philippines, Senegal and Sudan. Most training courses are specialized, with continuing divisions between each of the three major areas - engineering and hydrology; agriculture; and the social sciences. There are a large number of specialized training courses on the more technical aspects of irrigation.

On irrigation management in a broader sense there are fewer. An FAO source¹ lists 25 organizations which run relevant courses, of which 9 are in Europe, 6 in the United States, 3 in the Near East, 3 in Asia and the Pacific, 2 in Africa and 2 in Latin America. As described in more detail in Annex 3 in India a major facility for in-service training in water management is being considered at a cost of \$ 50 million during a five-year period (1983-1988) with USAID support. Pakistan is also planning significant training efforts. In both cases, national-level guidance in manpower planning concerning training (also personnel policies) is a priority.

Without a detailed review of current training curricula it cannot be said with authority that any aspect of irrigation training is not covered somewhere. Our general conclusion is, however, that current training falls far short of what is required, in style, content and scale. Too little training involves in-depth field exposure. The subjects covered usually neglect management practices. And the scale of training, even where the style and content are appropriate, falls far short of that required to reorient and retrain whole bureaucracies.

4.4 Information Exchange and Professional Networks

1. *The International Commission on Irrigation and Drainage.*

The ICID is a professional association, mainly but not entirely of engineers, with national committees in 78 countries. In some countries only engineers can be members; in others, other professionals concerned with irrigation can also join. Its headquarters in New Delhi house a library which has 20,000 volumes and takes over 200 journals. Its council meets annually, and every three years a congress is held. The ICID publishes a bi-annual bulletin and an annual

¹ Document W/P272X, 1981

bibliography. It has working groups on specialized subjects, one of which is being set up on irrigation water management. ICID collaborates with FAO in matters concerning the dissemination of information about irrigation and agriculture. ICID is promoting a proposal to set up an international documentation centre for data and information on research on irrigation, drainage and flood control.

2. *The Irrigation Management Network of the Overseas Development Institute, London.*

The Overseas Development Institute, a non-government organization, has an Agricultural Administration Unit which runs three networks, of which irrigation management is one. This network has about 600 members in more than 50 countries. The majority of members are in developing countries. Members include people from a wide range of disciplines and experience with a common interest in irrigation planning, design and management, including engineers, agriculturalists, economists, anthropologists, sociologists and administrators. Membership is free and members receive newsletters and discussion papers, and contribute to the network through correspondence. The irrigation management network has been operated by one person on a part time basis for about five years during which it has amply proved its worth. Its future must to some degree be linked with the manager who has run it so far. Were the network not to continue, a serious gap would be left.

3. *The Agricultural Development Council's Asian Regional Irrigation Communication Network.*

This network, based in Singapore has had a geographical focus on Asia. It has distributed a newsletter free to members, circulating details of recent publications and of research in progress. Since its manager returned to the United States, it has ceased to operate pending a possible replacement.

4. *The International Irrigation Information Centre, near Tel Aviv.*

The IIIC is a clearinghouse for information about irrigation. It publishes a quarterly newsletter, *Irrinews*, together with quarterly abstracts, and replies to requests for information. While international in its scope, and not limited to high-capital water-sparing approaches, its location gives it special competence in drip and sprinkler irrigation.

5. *Professional Interchange Unit, Indian Institute of Management, Bangalore.*

This unit promotes interchange between professions and disciplines, including the engineering, agricultural and social sciences, in the field of irrigation management. It publishes *Wamana*, a bulletin of information and comment, which includes descriptions of current research and references to significant recent publications across a range of disciplines. Although much of the material is from India, *Wamana* has an international circulation.

6. *Other Information Systems.*

A great number of other information systems cover a wide range of subjects and disciplines with some relevance to irrigation management. These include the International System for the Agricultural Sciences and Technology (AGRIS), the World Science Information System (UNISIST), the Current Research Information System (USDA/CRIS), the Permanent Inventory of Agricultural Research Projects in the European Communities (AGREP), the Database Guide for European Association of Information Services (EUSIDIC), the Commonwealth Agricultural Bureau (CAB), and the National Agricultural Library of the USA (AGRICOLA).

7. *Periodicals.*

Articles about irrigation management are published in a wide variety of periodicals in the fields of agriculture, engineering, natural resources, economic and social sciences, management sciences etc. At least 40 periodicals can be listed which from time to time publish articles dealing with certain aspects of irrigation management.

Useful though all these information sources and systems are, none combines all the characteristics which the Study Team considers necessary now in irrigation management. What is now needed, in addition to and complementing these current efforts, is an information system which is:

- highly selective, passing on only what is most useful;
- international in scope;
- cross-disciplinary;
- concerned with improving the management of irrigation systems;
- focussed on conditions in developing countries where small farmers are involved;
- directly linked-in with findings from action research;
- able to pick out and report on improved management practices;
- backed by resources which ensure good coverage and continuity.

Several international organizations have been active in promoting research, training, and information exchange on irrigation management. The World Bank has helped to set up training institutions such as the Water and Land Management Institute at Aurangabad in India, visited by the Study Team, and has sponsored and supported research on irrigation management, action research, international visits by key officials, and relevant institutional change. The Ford Foundation, in India, The Philippines, Indonesia and elsewhere, has encouraged and supported many pioneering initiatives in research, action research, and professional training and interchange. Other funding organizations such as UNDP, the Rockefeller Foundation, and the Asian Development Bank, have also played their part, as have bilateral donors. At the risk of failing to give due weight and recognition to these and other efforts, there are three multi-activity international programmes to which we wish to draw attention: FAO's International Support Programme for Farm Water Management; IRRI's Irrigation Water Management Programme; and the USAID-supported Water Management Synthesis Programme.

1. *FAO's International Support Program for Farm Water Management (ISP).*

The ISP was established in FAO's Land and Water Development Division in December 1980, and has a staff of three professionals. It is designed to respond better to the increasing needs of governments for assistance in improving the distribution and use of water among the small farmers as a prerequisite to producing more food and achieving a more equitable farm income distribution. The focal area is the farm level but the strong dependence of farm-level management on the overall system's management makes it imperative for the ISP to deal with all physical components of the irrigation system, and all parties at all levels involved in their management.

The ISP has two major areas of activities. The first is at the farm and village level, with the implementation of pilot improvement projects cum training programs. This emphasises assistance to farmers and field assistants, farmers' participation, low cost technology, and the use of local manpower, materials and resources.

The second is at the national government level, with the build-up and strengthening of the national capacity to support, coordinate and guide the farm/village level programs. This includes the build-up of

national research capacity to handle field level problems, promoting institutional arrangements such as the establishment of Irrigation Extension Services, and the build-up of national educational capacity through the introduction or strengthening of teaching programs in water management at selected universities, colleges and vocational training institutions.

FAO has over the years organized 20 national workshops on farm water management, and will in 1982-1983 organize two international seminars in Manila to discuss Philippine experience with small-scale irrigation projects.

While the main stress of the field projects at national level is on the farm level, farm water management, and farmers' participation, the research and training undertaken and proposed by the ISP is not limited to that. Of particular interest is a project for integrated water management in Indonesia, designed to establish an integrated training course on water management for agriculturalists and engineers on a pilot area; and to develop related field courses at appropriate locations in other provinces. The project is also to provide support to promote improved farm systems, undertake training of lower level irrigation and agricultural staff, and disseminate information on improved water management systems through publications and national seminars.

2. *IRRI*

IRRI has pioneered action research on irrigation systems. Although its Department of Irrigation Water Management has only two senior professionals working in this area, IRRI has collaborated with the Philippines National Irrigation Administration to make a major contribution, not least in drawing international attention to the potential from improved main system management.

IRRI's continuing and projected work in this field includes studies in the Philippines for irrigation system management based on reservoir storage, for pump system management, and for farmer organisation. Economic studies of irrigation management alternatives, and water use and rice yield studies are also continuing or projected.

In addition, IRRI has initiated two water management studies outside the Philippines and in collaboration with national research and government institutions: in Bangladesh, to develop effective methods of improving allocation and distribution of irrigation water and to

test the effects of optimum levels of soil, water and crop management on yields; and in Indonesia, to increase the production of rice and other crops through better use of available irrigation water and increased cropping intensity and to study the constraints to high yields in selected simple irrigation systems.

IRRI also conducts a 6-week irrigation water management training course, with the purpose of developing in the participating national agencies a core group of personnel knowledgeable in the relevant concepts and procedures for efficient management of irrigation water.

3. *USAID's Water Management Synthesis Project.*

This program is implemented by a consortium of United States Universities - the Consortium for International Development. Colorado State University and Utah State University serve as lead universities for the project. Two main activities of the program are farm-level action research and training.

Earlier action research was carried out in Pakistan on the Mona Project, and now Colorado and Oregon State Universities are involved jointly with the Egyptian Water Research Centre at three sites in the Nile Valley (see Annex 3). This action research seeks to identify constraints to improved water management, optimal irrigation and related agronomic practices at the farm level, and optimal operation of the delivery system. It is also concerned with farmers' participation and extending the lessons learnt.

In training, the program develops materials for on-site training courses, and manuals for improving water management. Innovative on-site training courses for professional development have been successfully held in several countries, most recently in India. These courses have involved participants in detailed on-field multi-disciplinary investigations and diagnosis of problems. Further courses are planned.

4.6 Conclusion

These and other multi-activity international programs promise to continue to make useful contributions. Each has its particular strengths. FAO's International Support Program is focussed primarily on the farm and national levels and has links with agricultural institutions. The

IRRI program covers both main system management and on-farm area management and is specialized on rice cultivation in the humid tropics. USAID's Water Management Synthesis Project is concentrated in certain countries and also stresses the farm level. The Study Team considers these and others to be valuable efforts, but recognizes that they do not, and cannot be expected to, cover all the gaps and needs for research, training and information in their full international scope and range of aspects.

5.1 Introduction

Current efforts, valuable as many of them are, cannot and do not fully meet the needs of the situation. They cannot and do not meet them in terms of scale and volume, although as their priorities are recognized, they may, as they should, do more and receive more resources. More pointedly, for our purposes, these efforts leave largely untouched certain key management activities and certain aspects of research, training and information. These gaps are rarely absolute. But as we shall argue in this Chapter, the needs and opportunities are so great, and so little is done, that further special attention is required.

One approach is to note lessons of weaknesses and strengths in some current efforts. These suggest three principles:

First, taking the *whole system* as the initial unit of analysis. Quite often there is overconcentration on one aspect or area of an irrigation system without prior attention to the whole. The whole system here includes physical, agricultural, operational and institutional dimensions, together with system's environment. Appraisal of the whole system is a necessary stage, while interventions often have to apply initially to parts of systems.

Second, *multidisciplinary*. Narrow disciplinary perspectives, and the omission of the concerns of any major discipline or group of disciplines (especially engineering, hydrology, soil science, agronomy, agricultural economics, sociology, and management) can generate misleading diagnoses

and ineffective prescriptions. Some aspects of irrigation are also left unilluminated as gaps between disciplines.

Third, a *field orientation*. Analysis and activities to improve irrigation management must be rooted in field realities. Diagnostic analysis, planning, design and operation must all be practical, field-tested, and implementable given the constraints of the real world.

These three principles are not often implemented together. Whole systems are analysed, but by one or two disciplines only. Multidisciplinary field-based diagnoses are undertaken, but mainly below the outlet. These partial analyses leave gaps in diagnosis, prescription, and understanding.

A further general point, already stated in Chapter 4, is the Study Team's conclusion that institutional arrangements, often a major impediment in irrigation systems, are best approached from within but that outside support in research, training and information can be effective in stimulating improvement in institutional arrangements.

Against this background, there are major activities which are inadequately covered, or scarcely touched at all, and where we consider a special international initiative to be the most cost-effective way forward. These activities are action research; research on practices for management; training for professional development; and disseminating selected information.

Action Research

The Study Team sees action research as a prime means of giving expression to these three principles. The broad term 'action research' covers several approaches,¹ but all are field-based. Action research can involve a small communal or a whole large system, or part of a large system such as an outlet, a minor, a distributory, or a branch canal. The area covered may usually be in the range between 100 and 10,000 ha, though it could be less or more depending on conditions and needs.

¹ For further description and a preliminary list of action research projects please see Annex 4

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Action research, as currently understood, requires the choice, introduction and testing of interventions on live irrigation systems, typically with six activities:

- diagnostic analysis and the choice of interventions
- benchmark surveys
- action taking
- monitoring and evaluation
- identifying lessons
- extending the learning to others and elsewhere

Ideally it involves collaborative learning between farmers, researchers, and project staff. It is iterative and adaptive, able to move through stages, starting with easier interventions such as changes in water scheduling, other management procedures, and minor infrastructural improvement, and subsequently moving to changes in cropping patterns, farmers' organizations, staff incentives, and organizational structures. Action research allows for interventions tailored to local conditions. It can provide a learning laboratory for understanding the problems and potentials of irrigation management and for use in management training. It also presents points of entry into a sequence of changes in part of a system which may later come to encompass the whole system.

The methods and problems of irrigation management action research are becoming better understood, and action researchers and others have begun to share their experiences.¹ But much more is needed in bringing action researchers into contact with one another, in collating and sifting experience, in developing replicable methods drawing on the techniques of different disciplines, and in training for action research. Questions to be addressed include methods of diagnostic analysis to select interventions; problems of ensuring reliable data; overcoming the pilot project syndrome with unmonitored special inputs; relationships between researchers and project staff; problems of interpretation, including multiple causality; possible short cuts through modelling; the use of action research as a way into other activities and questions, including

¹ For example, in September 1981 an International Seminar on Field Research Methodologies for Improved Irrigation Systems Management was organized by the College of Agricultural Engineering at the Tamil Nadu Agricultural University, Coimbatore.

training and institutional development; and the replication of interventions which have been successfully tested.

Action research is a high-risk activity with high potential payoffs, and for all its difficulties, it appears a realistic, practical and cost-effective approach to improving irrigation management.

5.3 Research on Practices for Management

Both flowing from and complementing action research, research is needed to identify, analyse and improve practices for key activities associated with irrigation management. The most important are those which have received less attention, or which are so central that improvements to them should bring high benefits. Without excluding others the Study Team wishes to draw attention to the potential of five activities:

1) *Diagnostic analysis.*

The term diagnostic analysis is used to include the appraisal of an existing irrigation system, analysis of problems and opportunities, and then choice of interventions to improve performance. Diagnostic analysis is quite often carried out, but has rarely if ever been studied and developed as an activity in its own right for a whole system. The work of the USAID-supported Water Management Synthesis Project (see Section 4.5), has been close to this, but its main focus has been at farm rather than system level. In practice, most appraisals and diagnoses are carried out by one or a few specialists, each predisposed to seeing the problems and prescribing the remedies of his own discipline. Agricultural economics and management are rarely included, and farmers' perceptions and insights are often neglected. The need here is, drawing on existing experience, to develop and test new methods of cost-effective diagnostic analysis for wide use to identify optimal sequences and mixes of feasible improvements.

2) *Information systems for monitoring and for system management.*

The priority of improved monitoring and communications has been repeatedly stressed to the Study Team. Managers of irrigation systems often do not know what is happening on different parts of their

systems or how well they are performing. Quicker and more accurate responses to rainfall and to changes in localized demand are difficult or impossible when the information needed is not available to the right person at the right time. There are often no reliable data on crops planted and their water requirements, on water deliveries, on the equity of water distribution, on water deficiencies and excesses, or on crop production. Managers with inadequate information find it difficult to pinpoint and change inefficient practices, and cannot fully use the capacity they have to control water distribution.

3) *Water scheduling and delivery.*

Operational decision-making about water distribution on main systems is not yet a major focus of professional attention on most of the projects with which the Study Team is familiar. Water scheduling is often governed by established conventions, rules of thumb, and local pressures rather than by agricultural needs and equity. The imperative for more fine-pointed water distribution to achieve a better fit with crop water requirements needs no emphasis. But water scheduling and delivery receive negligible attention in most training curricula for those who manage irrigation systems. The need is to compare existing techniques for scheduling and delivery of water on systems where clients are large numbers of small farmers; and to devise improvements, raising the status and interest of main system water management and investing it with more professional prestige.

4) *Institutional development.*

A neglected dimension of the management of irrigation systems is the management of people. Irrigation systems are complex in human organization, the larger ones involving a dispersed bureaucracy, and all involving farmers and their organization. There are three levels at which methods of management need comparative analysis and development.

First, the management of irrigation staff themselves. This includes administrative procedures, personnel policies, incentives and rewards, facilities, and training, and the relationships between these and system performance. Although frequently pointed to as a problem area, this has received little systematic research and development.

Second, farmer participation and organization. This has received more attention, though much is at the level of rhetoric. More needs to be understood about the relationships between farmer participation and the characteristics of the water supply delivered to farmer groups.

Third, the interface between farmers and irrigation staff. Much of the efficiency of a system can depend on the extent to which farmers' needs are communicated upwards and on the confidence they have in water deliveries. The different arrangements and dynamics of this interface are insufficiently understood.

5) *Planning and design.*

The frequency with which poor performance is traced back to errors or lack of foresight in planning and design prompts the Study Team to stress the need to improve their methodologies. Tendencies to overlook or ignore crucial physical, agricultural, operational and institutional factors, and to adopt narrow project objectives, limited to economic, financial and production targets, have contributed to disappointing performance. For the future, planning and design require stronger attention to factors neglected in the past at high cost, such as transmission losses; operation requirements in relation to crops, water availability, and rainfall; on farm facilities; farming systems; and farmer participation.

5.4 Training for professional development

Much current training is based in the classroom rather than in field realities. While classroom work is needed, it has to be offset and reoriented by field exposure. There is much to be said for the use of training materials derived from recent field experience, and for training activities which take place in field situations.

Realistic and useful training can take many forms. Diagnostic analyses by multidisciplinary teams are one excellent device, used for on-farm development in a recent training programme in Gujarat in India. Action research projects, as field laboratories, generate a wealth of information and insight which can be shared. Simulation games, based on realistic information, are a powerful tool for learning and for changes in

awareness. In Sri Lanka recently, for example, an action research group devised and used a simulation game to enhance awareness and develop insights into the problems to be faced in a rehabilitation programme. Some of the training most badly needed is in management practices which themselves are imperfectly understood and developed. These include those practices which are priorities for research and development: multidisciplinary diagnostic analysis for whole systems; main system management including the scheduling and delivery of water to small farmers, and methods for monitoring and control; the management of irrigation staff; farmers' organizations; communications with farmers; planning and design; and methods for action research.

One way forward is a composite, evolving, field-based, experimental approach, combining action research, improved irrigation management practices, simulations and on-field training. Such an approach should develop new training methods, and new materials for use in curriculum development. As good methods and materials are developed and proved, they can be used in training trainers. While this is not the only approach, it looks a fairly direct route to better irrigation management.

5.5 Disseminating selected information

Irrigation management is a rapidly evolving field, attracting more and more attention, and an information explosion is gathering momentum. As it becomes clearer that irrigation managers must have a multidisciplinary understanding, so also the amount of information relevant to them increases. In the next decade it will be increasingly difficult for professionals to keep abreast of developments. At the same time, high-yielding innovations in management already exist, and others will be developed locally in different places. Research and development on the five key activities listed above should also generate methods which deserve to be widely known. For these reasons, *dissemination must be selective*. A group is needed with the competence, disciplinary range, intellectual rigour, and courage to pick out only the small percentage of information that is good and a practical help; and then to disseminate only that.

The valuable work of the ICID, the excellent network of ODI, and other information sources cannot be expected adequately to cover this need. A special effort is required to accelerate mutual learning between projects, countries, regions, and disciplines, and between researchers and practitioners. A new initiative is needed:

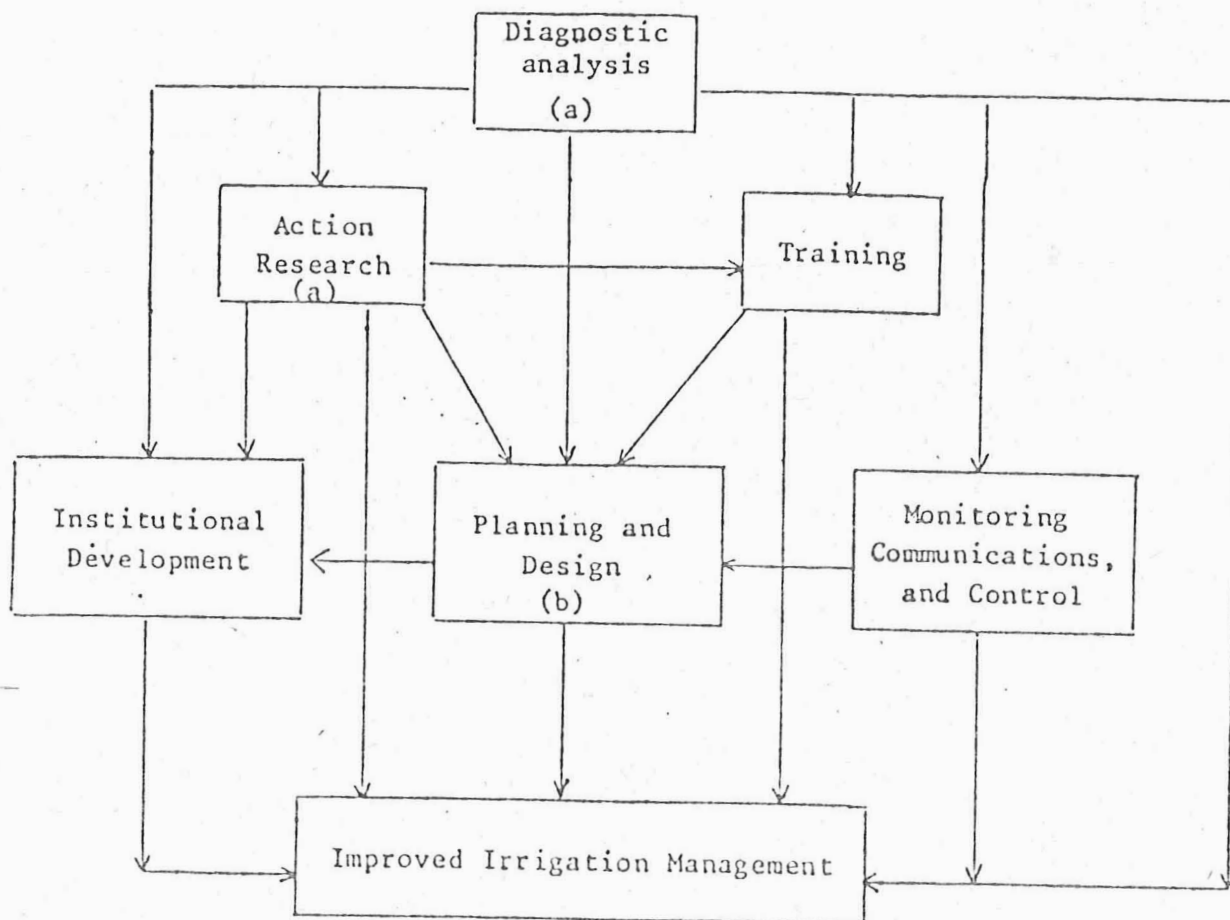
- a) to set up specialized networks in carefully chosen fields such as action research and system management practices;
- b) to organize site visits to enable policy makers, project managers, and others to learn at first hand about proven techniques and promising innovations;
- c) to promote selective research, workshops and conferences to advance understanding and dissemination.

5.6 A balance between activities

Some of the key activities for improving irrigation management are presented in Figure 5.1. This shows linkages between activities and some of the more important connections and possible sequences. Points of entry will differ. The best balance will vary by country and by project. We have selected priorities which have some general validity, but to which there will be local exceptions. For some countries and projects, the priority may be planning and design; for others, diagnostic analysis of existing projects leading straight to improvements. Activities like water distribution, or rehabilitation, can sometimes be improved at once through obvious and dependable reforms. Nothing said here should undermine such efforts.

But there is also much that is new that needs to be done. Action research, research on management practices, new methods and content for training, and disseminating selective information are none of them being pursued with anything like the energy, imagination and resources that they deserve. Unless a good international effort is mounted, there is no prospect that anything like the full potential of those activities will be realized.

Figure 5.1. Some principal linkages between key areas and activities



Notes:

(a) = of existing systems

(b) = for new systems and for rehabilitation of existing systems

1. Disseminating selected information applies to *all* areas and activities.
2. Feedback flows will occur along most if not all of the linkages.
3. Relative priorities, and optimal points of entry, will vary by country and by project. Diagnostic analysis may, however, be a common starting point.

6.1 Requirements of a New International Initiative

In Chapter 5, it was concluded that outside support to national efforts for improvement of irrigation management can best be approached in the fields of research, training and information.

Besides purely national efforts, several activities of an international nature are essential as a supplement. These are:

- (i) research to identify, analyse and improve *methodologies* as for diagnosis, monitoring, water scheduling, institutional management, etc.;
- (ii) means of exchanging, among countries, of experiences from action research;
- (iii) establishing required training centres in irrigation management in close liaison with institutions in host countries;
- (iv) conducting international seminars, workshops and study tours on topics pertinent to improved irrigation management; and
- (v) conducting studies to determine priorities for more rapid realization of irrigation potentials worldwide.

Support to national efforts in research, training and information including these five activities of an international nature just described would have at least four additional positive effects. These have not yet been mentioned in this report but they were repeatedly stressed to the Study Team by senior officials in the countries visited. An international initiative can further contribute to national efforts:

1. *by supporting activities in irrigation management through encouragement, promotion, and catalysis.*

A point repeatedly made to the Study Team was that a sensitive external initiative can have an enabling role, so that new activities can more easily be undertaken. It can, for example, facilitate collaboration between disciplines and between agencies (such as Ministries of Agriculture and Ministries of Irrigation, or between government agencies and university research institutes). Whether through discussions, participation, or flexible funding for action research and training, it can help to legitimate and catalyze activities which otherwise would be more difficult and take longer.

2. *by assembling an adequate mix of disciplines.*

Nationally there are often institutional rigidities which make it difficult to assemble a wide range of disciplines, including adequate and balanced representation of engineering, agriculture and the social sciences. It has been convincingly argued to us that there is need for a sort of think-tank, or forcing house for new ideas, values and approaches, which would be difficult to set up nationally.

3. *by raising the professional status and interest of irrigation management.*

A widespread difficulty in promoting improved irrigation management is the low status accorded to the management of irrigation systems, so that it does not attract the most able staff, is neglected in education and training, and has under-developed or poorly understood techniques. It has been repeatedly stressed to the Study Team that international attention to system operation would raise its status, prestige and professional satisfaction, and help to attract higher calibre staff for irrigation system management.

4. *by promoting confidence among decision-makers, both national and international, in irrigation investments.*

A new international initiative, adequately mounted and staffed, should serve to raise the confidence of decision-makers that irrigation management problems were being adequately addressed. This should help to justify the needed very large investments (see Chapter 2) in rehabilitation, research, training, and new irrigation projects.

In the light of all evidence and arguments presented, the Study Team considers the case for a new international initiative to be overwhelming. Its optimal form, however, needs careful consideration.

Our terms of reference require us to weigh five alternative courses of action. In the light of the argument and evidence to this point, our views are as follows:

Alternative a

'No involvement from the Consultative Group other than encouragement of international support for irrigation water management'

The Study Team, in line with the main thrust of its terms of reference, has based its practical proposals within a framework of CGIAR support. We do not feel fully competent to make a judgement to what extent the CGIAR is the appropriate body to initiate and oversee the initiative we propose. There are obvious strong advantages, including the established reputation and organization of the CG.'

As the report has tried to show, the problem of irrigation management requires early and adequate action. If the CG decides it is not able to carry out the needed action, some other agency would have to do so, clearly with CG support. However, since we are in no position to determine which agency and on what terms, we are unable to consider this alternative further.

The CG is an organization with a predominantly agricultural focus. A practical problem therefore to be faced is that irrigation management is almost universally dominated by the discipline of engineering, and that whatever is done will need the active support of professionals in that discipline.

Alternative b

'Formation of an institute as set forth in TAC's 1980 proposal'

TAC's 1980 proposal was for an institute to develop the knowledge, principles and expertise required for improving the design, operation and management of irrigation and drainage systems at various levels. The ultimate objective was to create independent national competence, starting with a better awareness among policy makers and a political will to give sufficient priority to the improvement of irrigation water management and a growing involvement of national universities and other research and training institutions in this field. This was to result in

a national capacity to field multidisciplinary water management teams both in research and in management of irrigation systems in countries where irrigation and drainage are important.

As far as its structure was concerned, the institute was to have a principal unit, located in an area where irrigation was a major concern in agricultural production, and which provided easy access to a wide range of irrigation problems. Ultimately, the institute was to have two or more satellite units, located in substantially different ecological zones. The institute would have a relatively light investment in permanent buildings and require an area of about 10 ha of land.

The Study Team fully agrees with the objectives formulated for the institute. The only difference is over the means to achieve those objectives. The 1980 proposal appears to the Study Team to be somewhat over-centralised. Contacts and work are desirable within a larger rather than smaller number of field situations and conditions. What is required is an institution very different from the major crop-oriented IARCs. The 10 ha of land at headquarters implies on-station research which would be a distraction from the field orientation and close collaboration with and support for national efforts which are essential. The Study Team therefore does not recommend that there should be any headquarters land for research. Offices are all that is required, combined with good access to existing irrigation systems.

Alternative c

'A model along the lines of an international service, operating in, and using the facilities at a limited number of selected irrigation systems in a few participating countries'

This model fits to a large extent the operational requirements of the activities seen as priorities by the Study Team. Here again, however, we would stress the need to collaborate with and support national efforts, not just to use the facilities of selected irrigation schemes, and the need for involvement in a wider rather than more limited range of local irrigation management situations.

Alternative d

'Feasibility of existing IARCs undertaking water management in their ecological environment and the extent to which this might or might not meet the requirements'

IRRI's efforts in irrigation management have shown that an existing IARC can make a very valuable contribution. ICRISAT has also undertaken useful work on aspects of small tanks, and on small watershed management. The emphasis which we place on *irrigation* management rather than *water* management (see definitions) does, however, serve to distance what we see as needed from the predominantly crop orientations of most of the existing centres. IRRI's irrigation management work should fit in well with any irrigation management initiative by the CG, and could become part of a decentralized organization. Other IARCs might service and support staff working on irrigation management. Precedents exist, such as CIMMYT staff at CIAT, for one centre providing a home for staff from another. Details of possible assistance of this sort should be worked out. The Study Team wishes to stress forcefully, however, that irrigation management cannot be expected to receive the full attention it deserves if it is only part of an existing centre, or lodged at existing centres, having to compete for funds with other activities which may be more focal to the concerns of those centres. Nor could it be expected to receive the direction and advice it needs without its own leadership and governance. Those with responsibility for irrigation management in host countries must of course also be closely involved. But the crucial point here is that the effort must have its own separate funding and unique and recognizable governance.

Alternative e

'Any other approach which might be suggested as a result of the study'

The approach recommended by the Study Team does not correspond exactly with any of the alternatives a through d, though it has elements of b and c and does not overlook some possibilities of d.

6.3 Approach Recommended

In view of the requirements in Section 6.1 and the alternative selected in Section 6.2, but taking into account also probable fund limitations,

the Study Team recommends an international initiative on irrigation management organized as a network with a small headquarters. The network would link national efforts especially in irrigation management action research and training, and provide selective support for them, partly through outposted staff. The headquarters would have a critical multi-disciplinary mass.

This initiative would combine elements of a network, of a service, and of a headquarters. We therefore recommend the title institute, the whole to be called the International Irrigation Management Institute (IIMI).

Levels of National Involvement

Considering the great variation among countries not only as to needs and requirements but also as to desires for international support and willingness to cooperate with such support; the Study Team proposes six possible levels of international involvement as shown in the following matrix:

Increasing levels of involvement	I	II	III	IV	V	VI
Information, seminars, workshops	X	X	X	X	X	X
Action research in network		X	X	X	X	X
Action research actively supported			X	X	X	X
Training partially funded				X	X	X
Regional training					X	
Support for national irrigation manage- ment centre						X
International staff:						
visits	X	X	X	X	X	X
in residence	-	-	0-2	1-2	1-3	2-4

The number of outposted international staff in each country involved would thus vary from none to four. The number could, however, be raised if funding and agreements were forthcoming.

Level I

There is no direct involvement of an international initiative on the national level. The country concerned may wish to limit itself to use only of the information system, and seminars, workshops, etc.

Level II

The country may wish to link its ongoing research activities into an international network in order to facilitate the exchange of information for the benefit of the country itself, but also to make its own experience more accessible to other countries. Apart from occasional visits there is no direct involvement of and support from an international effort.

Level III

In order to facilitate the implementation of action research a country may wish to ask for international support through partial funding and/or staff support. Visits of international staff and consultants, and outside contracts for specific studies, could be part of the international support.

Level IV

Action research is combined with national training in irrigation management. International support could include partial funding, staff support, visits of international staff, consultants and outside contracts for action research as well as for field-based training.

Level V

International involvement in a certain country would include regional training, which means that (internationally supported) action research provides a possibility for setting up and supporting regional training courses for irrigation management, preferably linked with national efforts in this field.

Level VI

If a certain country decided to set up a national irrigation management centre with a broad mandate to deal with all kinds of problems related to irrigation management, such a centre could act as a focal point on the national level through which international support could be channelled, not only for action research but also for national (and/or regional) training and for other key activities such as: improvement of standards for feasibility studies; cost-effective methods for diagnostic analysis of on-going projects; improvement of institutional and personnel policies; and coordination of research efforts.

The levels of involvement of the international support desired by a particular country would be subject to negotiation in each case. The level of involvement might be low at first, starting for instance with action research but gradually including other activities; equally it might be phased down or out over time.

Headquarters Activities

At the headquarters we recommend the establishment of a core staff with a multidisciplinary group which would work together in close collaboration. The activities of this group would include:

- conducting negotiations with countries desiring international support;
- setting up and managing an action research network, and other networks as the need and opportunity arise (see Annex 4);
- assisting in the preparation, implementation and evaluation of action research projects, and in the spread of their practical lessons, in support of and close collaboration with the national agencies involved;

- conducting studies aimed at determining priorities for more rapid realisation of irrigation potentials worldwide;
- identifying, analysing and developing methodologies for key activities;
- assisting in setting up national irrigation management centres and in monitoring their performance;
- organization of training including the development of curricula and of training methods;
- the establishment of training centres in close collaboration with staff of existing irrigation systems (or subcontracting with those institutions already working in this field);
- the selection and dissemination of information through networking, newsletters, and other publications and media, especially concerning the management of irrigation systems;
- the organisation of workshops, seminars and conferences on key management, research and training questions;

6.4 Governance

Three different levels of governance are considered: Governing Board, Programme Committee and Working Groups.

a) *Governing Board*

The Governing Board should be selected very carefully, due to the nature of the effort and its dependencies on activities which are considered basically as a national responsibility.

The members of the Board would be expected to serve in their personal capacity and not as instructed members of governments or their employing agencies.

Three different categories should be presented on the Board:

- Those having responsibility for irrigation management in developing countries. The main reasons for their presence on the Board are threefold: *First*, their personal knowledge on the question of irrigation management under field conditions in developing countries; *second*, they are the main beneficiaries of the results of the effort. Their presence on the Board is therefore necessary to give the effort the required utilizer orientation; and *third*, the cooperation of those in charge of irrigation management is required for

the implementation of the programme; at the national level first of all, but subsequently at the level of implementing an international network on action research and field-based training in existing irrigation systems.

- A second category consists of representatives (but serving in their personal capacity) from donor organizations. There are two reasons for their presence on the Board. First, certain donor agencies may wish to contribute directly to an international effort as proposed; and second, they may wish to coordinate or link their bilateral efforts with an international effort or with other bilateral efforts. Their presence on the Board could promote very much an interchange of experience and as such contribute to the efficiency of the overall effort to improve irrigation management.
- A third category would consist of members selected from among persons with broad experience in and knowledge of problems of irrigation development. The ability to consider and conceive new approaches and to think across multidisciplinary boundaries would be important.

As compared to existing IARCs the size of the Board would have to be relatively large as a result of the nature of the effort and particularly of its network character. In order to cover the three broad categories mentioned above, but also to include in the Board the major irrigation zones, a number of 20 members should be considered as an order of magnitude.

The major duties of the Board would consist of approving work programme and budget and give guidance to long term policy matters concerning the activities of the institute.

b) *Programme Committee*

The Programme Committee should be responsible for the preparation of the work programme and budget of the institute to be submitted to the Governing Board. The members of the Programme Committee should be selected on the basis of their professional knowledge.

It is advisable that the members of the Programme Committee should not be directly involved in implementing national activities. This does not exclude those in charge of implementing national programmes receiving direct support from the international programme, from participating in an advisory capacity in the activities of the Programme Committee, when the need is felt.

c) *Working Groups*

The possibilities of creating working groups for different purposes should seriously be considered, as a means of performing certain duties or tasks. Three different possibilities deserve mention:

- working groups for the preparation of regional training centres, seminars or workshops related to irrigated management;
- working groups on specific subjects in irrigation management, and the preparation of state of the art reports, with assistance from the international programme;
- regional working groups to discuss with the international programme regional matters and activities in irrigation management.

6.5 Closing Comment

The CGIAR has for many years been rightly concerned with the inadequate performance of irrigation systems in developing countries, given that improved performance is the key to:

- meeting forecasted food production deficiencies in the next two decades;
- promoting equity in income distribution and work opportunities, and other social benefits;
- preventing deterioration of the existing irrigation systems; and
- more effective and quicker results from the enormous investments being planned by national governments.

The concern of CGIAR has manifested itself in several inquiries and studies of which the present report is the most recent. The point now seems to have been reached when CGIAR must decide how to complete the task that it has assumed, namely, to take appropriate action on an international level to deal with the worldwide deficiencies in the performance of irrigation systems.

In Chapters 4 and 5, current national and international efforts to correct present deficiencies were shown to be seriously inadequate. An approach to correct the inadequacies is described in this Chapter. This approach will no doubt have to be improved, modified over time and is not without risk; but since the cost of delay is very high, it is a risk worth taking.

7.1 Staff requirements

Professional core staff at headquarters

As the international effort will emphasise cooperation with and support to national activities, and as the field laboratories will be existing irrigation projects, the size of the professional core staff at headquarters should be kept small. In order however to cover the earlier mentioned activities in an adequate manner, a minimum multidisciplinary mix is required.

In addition to the Director-General the staff should therefore comprise at least 8 to 12 professionals which should as possible include:

- one irrigation/drainage engineer with a civil engineering background
- one irrigation/drainage engineer with an agricultural background
- one agricultural economist
- one agriculturist, farming systems
- one rural sociologist
- one specialist in training
- one specialist for information and publications
- one management specialist
- one senior administrative officer

Irrespective of their disciplines, all core staff (this applies to field staff as well) should have a multidisciplinary orientation with proven experience through having worked on multidisciplinary teams, involving international collaboration in developing countries, preferably for a substantial period at professional level.¹ A practical and operational orientation will be highly preferable.

¹ One member of the Study Team considers that a minimum of ten years

The possibilities for covering certain disciplines through part-time consultants should also be kept in mind.

Supporting Staff at Headquarters

The headquarters would also have staff recruited locally for secretarial and administrative assistance. In addition, consideration should be given to the possibility of locally recruited technical staff to assist the professional core-staff in desk research that might be needed. Tentatively one might think of a total of five technical assistants to the professional core staff.

Professional Core Staff Outposted

The major tasks of the outposted field staff should be considered in the light of the basic principle that the tasks to be performed should as much as possible be performed by national institutions. The role of the field staff will therefore basically be complementary and geared to strengthening national capabilities.

Outposted staff will be involved in combinations of action research, national training, regional training and possibly the establishment of national irrigation management institutes. As has been explained in Chapter 6, different levels of international involvement can be distinguished according to the wishes of a particular country. In order to strike a balance between professional core staff at headquarters and professional core staff outposted it seems reasonable to assume a number of 10 outposted staff members.

Consultants

In order to keep the professional staff at headquarters as well as outposted at the lowest possible but still viable level, use should also be made of consultants.

Another reason is that action research and procedures required to define action research programmes on the basis of a multidisciplinary appraisal or diagnosis of prevailing conditions in irrigation projects will

require short-term high level expertise in specific fields. Some of the expertise should then be mobilized through the recruitment of part-time consultants. Such consultants should preferably be involved on a more or less regular basis, to guarantee a certain continuity in their input. With a total core staff (headquarters and outposted) of about 20 professionals, a total of 4 man-year consultancies per annum seems a reasonable although certainly not excessive proportion.

7.2 Other operational requirements

Outside contracts

A considerable amount of highly specialized expertise is available in existing institutions in many countries of the world. Such expertise should not be duplicated on the international level, but instead be tapped and mobilized according to needs resulting from the identification of those problems which constrain proper irrigation management. Outside contracts are a powerful tool not only to mobilize such highly specialized expertise to the benefit of the effort, but also to increase operational flexibility. Such outside contracts may also cover a wide variety of subjects of general interest.

Cooperative research programme

Partial funding of action research in the framework of a cooperative agreement with the institute, possibly combined with national or regional training could considerably increase the operational flexibility of the effort.

The funds would help provide support for salaries of key national staff engaged in action research projects and for limited physical facilities and equipment.

Training, fellowships, seminars and workshops

Training and exchange of information by means of seminars, workshops and study tours is an essential part of an international effort to improve irrigation management. Efforts in this field should focus on aspects of irrigation management and not on highly specialized subjects.

As no physical research facilities are required at headquarters there is some flexibility in choosing the location. Unlike the international agricultural research centres, the headquarters does not have to be based in a particular agro-climatic zone either. The choice of location can be made on the basis of other factors. One of those factors is that the headquarters should be located near the centre of gravity of irrigated areas in the developing world.

In giving further consideration to the matter, factors to be weighed include the operational efficiency of the institute and the legal conditions posed and privileges and immunities, especially in tax matters, offered by the host government.

Concerning these factors the following observations can be made:

- 1) Participation in national activities in irrigation management, including a wide range of conditions, is a basic characteristic of the effort. This means that headquarters staff will have to be on travel status for an important part of their time. Good communications in terms of air travel but also in terms of telephone, telex, and postal services are therefore important factors to be considered in locating the headquarters.
- 2) Research and comparative studies based on information collected from experiences from all over the world is another important activity of the institute. Proximity to good data bases as generally available in universities, research institutes and the like, would be an advantage.
- 3) A special aspect would be the ability to attract and retain staff. Among the items to be considered here are: cost of living; climate and health conditions; amenities (housing, medical services, schools, availability of goods and services); privileges and immunities accorded to international staff.
- 4) Operational flexibility is also affected by the availability of local man-power, technical as well as secretarial, good English language services and good printing facilities.
- 5) Location near the centre of gravity of irrigated areas in developing countries, as already mentioned.

Regarding this last factor, the Study Team has divided opinions.

One opinion favours location in a developing country prepared to give headquarters staff access to live irrigation systems. This would enable

the staff to maintain a practical field-orientation, and to have the multidisciplinary interaction with national staff necessary for developing generalisable insights, approaches, and management practices. Divisions of responsibility among core staff, and/or the addition of 'outposted' staff for national collaboration and liaison, would protect the time of core staff so that they would not become over-involved nationally and could perform their international responsibilities fully. A proper balance of these activities would be managed by the Director-General and would be monitored by the Governing Board.

The other opinion is that the question of whether or not the headquarters should be in a developing country should be left open for the time being until the practical possibilities considering the five factors have been adequately explored. Headquarters staff access to live irrigation systems in the immediate vicinity is not important if staff meet minimum experience criteria (10 years) and since staff will be expected to travel to the field frequently. Use of outposted staff to protect the time of core staff might not be workable. The main disadvantage of locating the headquarters in a developing country, particularly one with many irrigation management problems, would be the danger that headquarters staff would become too involved in local problems rather than in problems under differing agro-climatic and socio-economic conditions also.

7.4 Cost Estimate

Based on cost experienced in similar organizations, the Study Team contemplates an annual budget for the institute once in full operation of US\$ 4,500,000 per annum (1982 dollars), composed somewhat as follows.

	<u>US\$ per annum</u>
Core staff at Headquarters (10)	1,200,000
Staff outposted (10)	1,100,000
Consultants (appr. 40 months)	600,000
Research assistants	200,000
Travel of headquarters core staff	200,000
Rent and office maintenance	100,000
Outside contracts	200,000
Cooperative research programmes	300,000
Seminars, workshops, fellowships	250,000
Board, Programme Committee, Working Groups	150,000
Contingencies (5%)	<u>200,000</u>
	4,500,000

The budget for core staff at headquarters also contemplates for secretarial and clerical services and operational expenses. The budget for core staff outposted includes provision for local travel, relocation, etc.

ANNEX 1

TAC Steering Group on Water Management Research and Training

Dr. W. Treitz, Federal Republic of Germany, Chairman
(October meeting only)
Dr. R.K. Cunningham, Chairman (February meeting only)
Dr. L. Barraza, Inter-American Development Bank (October meeting only)
Dr. N. Collins, Ford Foundation (October meeting only)
Dr. P. Cros, France
Dr. R.W. Cummings, TAC Chairman
Dr. A. Hardan, Iraq
Dr. H.M. Horning, FAO
Dr. F. Hotes, World Bank
Dr. H. Idris, UNDP
Dr. K. Kanungo, India
Dr. G.J. Koopman, Netherlands
Dr. Amir Muhammed, Pakistan
Dr. D. Seckler, Ford Foundation (February meeting only)
Dr. F. Williams, USAID (later ISNAR)
Dr. M.S. Zehni, TAC Member

Dr. J.H. Monyo, FAO observer
P.J. Dieleman, FAO observer

P.J. Mahler, TAC Secretariat
L.H.J. Ochtman, TAC Secretariat

TAC Study Team on Water Management Research and Training

F.E. Schulze, Director, International Institute for Land Reclamation and Improvement, Wageningen, Netherlands (Team leader)
Dr. R. Chambers, Social Scientist, The Ford Foundation, New Delhi, India
Dr. M. Dagg, Agricultural Scientist, ISNAR, The Hague, Netherlands
(October 1981 only)
P. Kirpich, Irrigation Engineer, Consultant of the World Bank, Athens,
cece

ANNEX 2
TERMS OF REFERENCE
TAC Study Team on Water Management Research and Training

I Objectives

The primary objectives of the study, to be conducted by a team comprised of individual irrigation experts, are as follows:

1. On the basis of available reports (and additional information to be collected), to identify the extent to which training and research in irrigation water management are now being performed by:
 - a) existing IARCs;
 - b) existing principal water resources research institutes of universities in developing and developed countries;
 - c) existing institutions, such as FAO, UNDP, UNESCO, CEFIGRE in France and ILRI in the Netherlands; and
 - d) other organizations making significant contributions to training or research.
2. To determine the aspects of training and research activities in irrigation water management which are not receiving sufficient attention, which could provide significant improvements in irrigation water management in developing countries and which might be addressed more effectively through international - as contrasted to national - efforts in this area and to specify the contents of the research and training programmes which might be needed under various alternative courses of action as indicated below.
3. To formulate alternative courses of action for CGIAR support in this area and indicate the pros and cons of these alternatives such as the following and to identify the specific types of problems which would be addressed in relation to each:
 - a) No involvement from CG - other than encouragement of international support for irrigation water management.
 - b) Formation of an institute as set forth in TAC's 1980 proposal.
 - c) A model along the lines of an international service, operating in and using the facilities of a limited number of selected irrigation systems in a few host countries.
 - d) Feasibility of existing IARCs undertaking water management in their ecological environment and the extent to which this might or might not meet the requirements.
 - e) Any other approach which might be suggested as a result of the study.
4. To indicate how the above courses of action would be complementary to activities of other agencies concerned with this subject.

5. In the event that no involvement from CG is recommended (Item 3 a above), to identify present training and research efforts which should be continued or expanded, and to suggest new activities or steps which could be undertaken to improve and support irrigation project performance in developing countries.
6. It should be noted that 'irrigation water management' includes all activities from upstream at the point of diversion or storage to the point of on-farm use, and downstream to the point of disposal from the irrigation areas, and perhaps to the sea.

II Procedure

1. To recruit and assemble a study team comprised of one or two agriculturists, one engineer and one social economist, all experts in irrigation projects and with multi-country experience, under the guidance of a Steering Group, which in particular would supply expert knowledge of the CGIAR system and objectives. The Steering Group would include representatives of the main interested parties which were present at the ad hoc meeting of the CGIAR members on water management held on July 20, 1981.
2. The Study Team will assemble at FAO Headquarters for about two weeks for briefing, desk studies and formulation of preliminary observations. The Steering Group will meet with the Study Team at the end of these two weeks.
3. A briefing index of relevant documentation would be made available to the Study Team prior to their first meeting. At the first meeting a schedule would be prepared of visits to various institutions and operational irrigation systems in developing countries to obtain needed information not readily available otherwise. During these visits information pertinent to the first five objectives outlines above would be obtained specifically.
4. Field visits would be carried out to selected developing countries, some by part of the Study Team jointly, and if considered necessary, some by individual members of the team. Visits to some institutions in developed countries may also be arranged as required by the Steering Group and/or the Study Team.
5. The Study Team would re-assemble at FAO Rome following the field visits for discussion and drafting of the final report to TAC to be submitted by the Study Team leader to the Chairman of TAC by January 15, 1982.
6. The final report of the Study Team would be presented to TAC at the 27th Meeting, March 9-14, 1982.

ANNEX 3
CURRENT SITUATION IN SELECTED COUNTRIES

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(as cited by Indian officials)

Main System Inadequacies

On-Farm System Inadequacies

Faulty On-Farm Practices

Faulty Drainage and Road Systems

Faulty Farming Systems

ANNEX 3
CURRENT SITUATION IN SELECTED COUNTRIES

INTRODUCTION

- 1) This annex describes the current situation with respect to irrigation management in several countries that the Study Team visited and studied during preparation of this report or that they had knowledge of through previous visits and studies. Emphasis is given to problems still needing solution, what is being done currently to solve these problems and what remains to be done.

INDIA

Background

- 2) India has 60 million ha of irrigated land (Commanded Area), more than any country in the world except China. India's accomplishments since Independence in construction of irrigation works has been phenomenal with almost one million ha added per year on the average. About half of the irrigated area is in large and medium public schemes of over 2,000 ha; the remaining half is in so-called minor schemes, mostly small privately owned shallow wells. About two-thirds of the wells are equipped with electric pumps and the remainder with diesel, animal or human-driven pumps or lifting devices. The figure of 60 million ha represent the 'irrigation potential'; the area actually irrigated is about a fourth less or 45 million ha. The yield from this reduced area is moreover low compared with world standards. For example, the yield of irrigated foodgrains in 1950 was 0.9 tons per ha and, although there has been a substantial increase up to a current yield of 1.7 tons per ha, it is still low compared with world standards. Moreover, despite the rapid increase in irrigation potential achieved in the past three decades, per capita annual increase in agricultural production has averaged only 2.25%.
- 3) An overall objective of India's Sixth Plan (1980-1985) is to increase food production to about 150-155 million tons from the present level of 120-130 million tons. Apart from other inputs, this is to be achieved by increasing the irrigation potential by 14 million ha and through more efficient utilization of the potential already created. The latter would be accomplished by modernizing the older irrigation systems and by adopting better water management in these systems. The fact that only about 25% to 40% of the water diverted is delivered to crop root zones illustrates further the very large gap between the irrigation potential and what might actually be achieved through better water management.

- 4) A major part of the small-scale irrigation development to date has been in the form of private shallow wells, mainly in the Gangetic plain where about 12 million ha are presently irrigated from this source. The groundwater resource in this plain is more than ample to permit doubling of the area irrigated except that lack of energy and the many smallholdings are primary constraints. Although hydro-electric sources could be tapped, these are of high cost while international complications present difficult obstacles, again indicating that most of the additional agricultural production attainable through irrigation in the next several decades will have to come from modernization and from improved yields (including double cropping to the extent practicable) in the areas already irrigated.
- 5) The low present output of the Indian irrigation systems (not only according to yield but also according to the limited extent of double cropping despite favourable year-round growing conditions) has resulted, since the mid-1970's, in a substantial effort by Indian authorities to eliminate deficiencies. The main feature of this effort has been the setting up of 44 Command Area Development Authorities (CADAs) covering 74 major irrigation canals and serving 15 million ha. The CADAs, which had as a major objective improvement of on-farm water management, have had limited success. The reasons for lack of success, generally well understood by leading Indian officials, most often concern faulty enterprise-management-type practices but of equal or greater importance are faults in the main system (untimely or insufficient water supply), lack of drainage and roads, and lack of advice on appropriate farming systems for use by individual farmers.

Current Physical and Operational Inadequacies
(as cited by Indian Officials)

- 6) Appendix 1 of this Annex lists these inadequacies and gives references to the publications wherein the inadequacies were cited.

Needed Improvements in Main System Operation

- 7) *Addition of regulating structures:* In general, the canals are run either completely on or completely off. The canals are seldom operated at less than full capacity so as to save water when rains occur. To prevent overtopping of canal banks when rains occur, escape channels are opened which causes waste of water.
- 8) Operating engineers are giving thought on how operations can be improved to conserve water. In the Upper Ganga system in Uttar Pradesh, the Study Team was told that a detailed feasibility study is under preparation regarding the addition of structures, mainly cross-regulators, to enable improved operation. The additional hardware needed would include an improved telecommunication system.

- 9) *Addition of telecommunications:* The need for improved telecommunications is a typical deficiency in Indian irrigation distribution systems. Indian officials are well aware of the inadequacy and consideration is being given to the formation of a task force to determine *inter alia* whether the problem should be attacked nationwide, statewide, or as part of remodelling schemes for individual systems.
- 10) *Creation of separate operation and maintenance wings:* As indicated in Appendix 1, item B-1.3, senior Indian officials have recommended creation of separate operation and maintenance wings in the State Irrigation Departments. However, implementation of these recommendations is thus far being realized only in Maharashtra and in no other State.
- 11) *Addition of roads:* Lack of farm-to-market roads is often a serious drawback. A road plan should be included during preliminary planning of irrigation projects since it is difficult to add roads after the system is completed. The larger canals do have maintenance roads but the intermediate size canals need such roads also. The maintenance roads can be gradually upgraded to permanent roads. Similarly, when constructing drains, the excavated materials can be used to form embankments for the adjacent roads. The Superintending Engineer in charge of the Jayakwadi project in Maharashtra said that he was gradually convincing his colleagues to add maintenance roads along canals and to gradually upgrade them to permanent roads.
- 12) *Conjunctive use of groundwater and surface water* is already widely practised in the States of Punjab and Haryana. Exploitation of groundwater is mainly by small farmers employing shallow wells financed through agricultural credit schemes. In the newer projects in South India where water is as yet plentiful, waterlogging is occurring due to over-irrigation of rice but the waterlogging is being controlled through installation of shallow wells again by individual farmers with financing through agricultural credit. The pumped water is being used in the rabi season to supplement water that is not always available at that time from the canal system. In one such case visited by the Study Team, the impression was gained that, in view of the high energy cost for pumping, a horizontal system might solve waterlogging more economically.
- 13) *Canal lining:* Another element of the conjunctive-use problem concerns whether major canals should be lined in order to reduce seepage losses in cases where the seepage can be recovered through groundwater pumping. In flat terrain, lining is more practicable since a parallel lined canal can be constructed and the old canal abandoned. However, in cases, such as many in South India where the main canals are located in relatively sloping terrain (so-called 'contour canals'), construction of parallel canals becomes difficult and recovery of seepage through groundwater pumping then seems more attractive.

- 14) *Automation as a means of circumventing managerial difficulties:* Because of institutional difficulty and lack of training staff, thought has been given to hardware improvements that circumvent these constraints. For example, a tubewell project in Uttar Pradesh financed by the World Bank features push-button-operated wells that supply buried pipe systems equipped with hydrants to serve individual farms; operation and maintenance requirements are thereby greatly simplified. Another hardware improvement in some systems might include the installation of automatic float-operated gates for maintaining constant levels in canals. The latter possibility is expected to be under investigation in the near future by French consultants.
- 15) *Improved project planning:* The need for improved project planning capability is realized in some of the State Irrigation Departments but not all. Typically, a department has a Design Directorate and a Construction Directorate. The Construction Directorate usually assigns specific geographic areas to Divisions which carry out operation and maintenance as well. Almost none of the State Irrigation Departments have Planning Directorates. An exception is the State of Gujarat where a new Planning Directorate is being set up to handle planning for the large Narmada basin development.
- 16) A development of recent years is the formation of a consulting group, 'WAPCOS', which is a quasi-government institution devoted to preparation of feasibility reports for specific projects and sometimes final design as well. WAPCOS is also doing some consulting work outside of India. The Central Water Commission, an agency of the central government, also does a certain amount of project preparation work based on specific requests from State governments. In general, however, private or even quasi-public consulting firms to carry out project preparation are lacking in India. This places too much load on the State Irrigation Departments and is one reason why projects in India suffer from poor preparation.
- 17) Before an irrigation project goes forward, whether for a system serving a new area or for improvements to an existing system, a 'feasibility study' is required. Feasibility studies of proper standards need to be based on adequate 'project planning' concepts. In this connection, the following quotation from the comprehensive 1972 report of the second Irrigation Commission is pertinent. 'Many of our existing irrigation works, which were by all standards a creditable performance at the time when they were executed, are now proving too inadequate to meet the exacting demands of the new high yielding varieties of crops. These crops require not only timely irrigation but also irrigation in the required quantities.'
- 18) Planning and design standards have changed in the last two decades and they can be expected to continue to change as further development of HYVs takes place including short-duration varieties for which planting dates become more critical than before. The short-duration varieties might require less water but are more exigent regarding timeliness and peak water requirements, thus putting further constraints on planning and design of the distribution system.

Not only will canal capacities have to increase; it will also be necessary to find ways to add in-system storage and/or meet peak requirements through conjunctive use of groundwater.

Needed Improvements in On-Farm Systems

- 19) The purpose and scope of the Command Area Development Authorities (CADAs) was described in Para. 5. It was also mentioned that the CADAs have had less success than anticipated. A leading Indian Administrative Service official who had been in charge of the CADAs in Andhra Pradesh and with whom the Study Team spoke felt strongly that the main system has to be improved first to ensure adequate and timely supply of irrigation water, without which the establishment of CADAs may be premature. There are however cases where partial improvements of the main system can be carried out selectively without waiting for improvement of the entire system which will ordinarily take a long time.
- 20) *Improved institutional arrangements:* Reasons for ineffectiveness of many of the CADAs can also be traced in large measure to faulty institutional arrangements and personnel policies as already recognized by Indian officials; see Appendix 1, part B. In a project in Maharashtra that the Study Team visited, the CADA has been placed under the responsibility of a Superintending Engineer who operates the main system as well. This follows an institutional arrangement that had been recommended by a leading Indian official (Item 1.2., Part B, Appendix 1); however, this seems to be the only case of such an institutional arrangement.
- 21) *Adoption of rotational water supply:* The warabandi (rotational water supply) system is well established in Northern India, especially Punjab and Haryana, where it has evolved and has been in effective operation for a long period of time. Warabandi is a means of achieving equitable distribution of water according to size of landholding so that water is shared equitably even when in short supply. Elsewhere in India, warabandi is rarely practised or is not carried out as effectively.
- 22) Various improvements in warabandi operation are proposed such as:
(a) maintain the regular turns of individual farmers but throttle down the chak outlet when water supply is short (this would require an adjustable gate on the chak outlet plus added labour for operation) and (b) rotation of the minor canals as already practised in Haryana. The adoption of such modifications requires a form of action research within individual canal commands involving considerable evaluation and trial and error. In the newer projects in South India where extensive rice and sugarcane cultivation is practised in the upper parts of the canal commands, the introduction of such modifications would be further complicated since farmers at the upper end of the canal commands have developed a vested interest in the copious supplies of water that they now enjoy.

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- 23) *On-farm irrigation practices* in India leave much to be desired. The typical method in use is flood irrigation, with plot-to-plot distribution common, especially in rice-paddy areas. Borders and furrows are hardly ever used. The recently established Water and Land Management Institute at Aurangabad in Maharashtra has begun to experiment with borders and furrows and will be preparing a manual dealing with the subject. Among the many constraints which tend to prevent adoption by farmers of better on-farm irrigation practices, two are: first, that there is no practical way for charging for water volumetrically and second, that the farmers do not have appropriate implements with which to construct borders and furrows making use of the power available to them, namely, bullocks. A kind of 'component research' is needed to help solve this problem.

Monitoring

- 24) Monitoring of individual irrigation systems is not carried out in India in an effective manner. Although improved methodologies for monitoring are needed, pending their development there are some obvious monitoring tools that could be put into practice. For example, it would be useful to require for each irrigation system the publication and printing of an annual report listing production and equity targets and the degree to which such targets were achieved. Reasons could of course be given as to why such targets were not achieved or were over-achieved.
- 25) In addition to individual annual reports for irrigation systems, a summary report, probably by States, would be useful. A possible model is that of the Ministry of Agriculture and Water Resources of Mexico which prints such a summary annually. For each of the approximately 100 irrigation districts in Mexico, a 3-page summary is presented giving the cropping pattern, the crop yields, the total production of each crop and the water consumption in cubic meters.
- 26) *Rapid appraisal*: From 1975 to 1980 but mainly until 1978, a team set up by the Central Water Commission conducted a series of rapid appraisals of existing projects and issued a report 'Recommendation of Central Team on Water Utilization on 24 Existing Projects'. This document contains very short summaries, usually three page long, describing the constraints on the effective operation of the project examined. The time spent by the team on each project was about a week. The Study Team got the impression that the procedure used, one of quick appraisal, could be highly effective but it does not seem to have been followed up. Part of the problem seems to be that the CWC report was not taken seriously by the individual State Irrigation Departments.

Manpower Planning

- 27) *Personnel policies:* India's irrigation engineers (there are 70,000 presently employed) have shown a remarkable talent and capability in harnessing the gigantic rivers of the country by means of large and small dams, headworks, regulators and major canal systems. The same proficiency and dedication has not however been shown as yet in the field of irrigation water management (in order to derive full benefit from the irrigation potential created), a situation which is due, at least in part, to faulty personnel policies. Promotion is mainly by seniority and motivation for high performance is generally lacking. Rotation of personnel is often very frequent.
- 28) Irrigation engineers generally prefer to engage in construction rather than operation and maintenance; that is why leading officials have suggested the establishment of a separate cadre for operation and maintenance and to adopt regulations whereby engineers cannot transfer from the operation and maintenance cadre to the construction cadre (see Appendix 1). Perhaps this idea will have a chance of success since in many States construction will now have to slow down (owing to budgetary restrictions and since in some States there are few irrigable zones left) so that the higher yields and double cropping must now be realized from existing irrigation projects. On the other hand, since the central government and many States still plan to proceed with construction of new systems on a big scale (see below under Strategy of Development), the chance of success in setting up a separate cadre for operation and maintenance may not be bright.
- 29) *Training:* As was indicated in Appendix 1, Item B-3.1, a lack of facilities for in-service training in water management is well understood at a high level and steps are underway for creation of an in-service training institute in water management to be located at a site still to be chosen not far from Delhi. Training offered will be primarily for in-service engineers although non-engineering subjects will be included. The institute will be sponsored by the Central Water Commission's 'Water Management Wing' whose name is being changed from 'Water Research Wing'.
- 30) USAID is expected to participate in a substantial way in the financing of the new training institute. USAID is presently organizing a study team that will examine the question during a period of several months together with Indian officials in order to establish the scope and duration of the training to be offered and to prepare preliminary designs and cost estimates of physical facilities needed. The physical facilities would be limited to buildings since it is planned to use actual irrigation projects as training workshops. The order of magnitude of the cost envisaged is \$50 million over a five-year period beginning in 1983.
- 31) An obvious need to be fulfilled by the new training centre will be to prepare a manual on on-farm water management that has to be in non-technical language easily understandable by field staff many of whom will be diploma holders rather than university graduates.

- 32) Pending establishment of the new training institute, some efforts for in-service training in water management have proceeded. At Aurangabad in Maharashtra, a Water and Land Management Institute has been operating for two years with financial support from the World Bank. Two types of courses have been presented: long-term, 10-12 months and short-term, 8 weeks. Facilities are available for 60 long-term-course and 120 short-term-course participants, all of the Irrigation Department. A matter to clear up is whether agriculture extension personnel of the Agriculture Department should receive training in water management at the Institute.
- 33) At university level, the University of Roorkee has long been a world leader in training of hydraulic engineers and now is giving more attention to micro hydraulics and to problems of on-farm water management. The curriculum is also being widened to include more courses on agriculture, economics and sociology. Agriculturists rather than only engineers will also be admitted to courses at Roorkee although it is realized that the response from agriculturists is likely to be weak since training in water management is thus far of little value in advancement of their careers. The University of Baroda in the State of Gujarat is also giving attention to development of a curriculum in irrigation water management for which it has assistance from USAID,
- 34) Since projects of any kind, including irrigation projects, require effective leaders who can in fact come from almost any irrigation-related discipline (economics, management and agriculture as well as engineering) thought has to be given on how to educate and stimulate effective project leaders. Part of the reason for the scarcity of such leaders can be traced to defects in the university training presently available which is often overly focussed within a particular discipline. For example, outstanding engineers with ambition to become managers should receive some training in some of the related disciplines such as management, administration and economics, and in the humanities such as sociology.
- 35) A fairly effective device that has been employed recently with World Bank assistance has been to send irrigation engineers on visits to selected irrigation projects in various countries including the Philippines, Korea, Morocco and United States. Engineers with whom the Study Team spoke said that the trips were very valuable in broadening their thinking regarding alternative ways of dealing with water management. Still, what is remarkable is that even the various approaches utilized within India, which are often quite different, are not shared among the irrigation engineers of the respective States.

Information Exchange

- 36) Seminars are a good means of exchanging information and these have been conducted with good results on many occasions in India and nearby countries. To be most valuable, seminars must be adequately prepared, a task that should be coordinated and arranged by the new in-service training institute.

- 37) Another task for the institute should be issuance of a publication on perhaps a quarterly basis. The publication should be of high standard and should include a review of current literature on irrigation water management. Since the volume of such literature is very great, the review should concentrate on literature judged to be of early practical application.

Research Gaps and Research Coordination

- 38) There are many on-going research efforts in India but these are not being effectively planned and coordinated. A recent list of research needs in irrigation prepared jointly by the Ford Foundation and the World Bank described 21 such items in four groups (engineering, system operation, administration and socio-economics) for which research, if properly planned and coordinated, could be carried out by Indian universities and by Indian institutes of management or research.
- 39) In order to plan and coordinate the on-going and proposed research efforts, the central government has recently set up a coordinating panel to be chaired by the Vice-Chancellor of the University of Roorkee. However, in view of the enormity of the task, it is doubtful whether a coordinating panel that meets once in three to six months will be effective. The agencies involved include the Indian Council for Agricultural Research, various institutes (approximately 35 in number) that conduct crop research but also deal with soil/water aspects, the National Institute of Hydrology at Roorkee, the Water Technology Centre at Pusa near Delhi (supported by the Ford Foundation), and others. If the additional tasks in research proposed by the Ford Foundation and the World Bank are to be addressed, a large number of universities, technical institutes and management institutes will be involved, making the task of planning and coordination even more complex than it is already.
- 40) Three additional research gaps that came to the attention of the Study Team include:
- Development of appropriate farming systems including choice of optimum cropping patterns. Such research is needed to cover both the situation under existing conditions (which take account of current deficiencies in the water delivery system) and under improved conditions (with some or all the deficiencies removed). The farming systems need to be examined from the farmer's point of view, take into account his capability to overcome the physical and other constraints.
 - Development of an appropriate cropping system for black cotton soils of which there is a very large total area in India. Many of these black cotton soils are in zones of relatively high monsoon rainfall which make them difficult to cultivate when wet (they are then highly plastic) or when dry (they are then very hard). In many parts of India, the black cotton soils are not cultivated at all during kharif.
 - Development of implements to enable the farmer to form borders and furrows using bullocks; see paragraph 15.

Irrigation Development Strategy

- 41) The year 2000 target mentioned by many Indian officials is to reach an irrigated area of 113 million ha which compares with the presently irrigated (commanded) area of 60 million ha. During the six-year plan period 1980-1985 it is proposed to spend \$15,000 million on irrigation of which only 10% would be devoted to modernization (in an area of 14 million ha). Achieving such a target would require an annual rate of expansion some 50% greater than that achieved in recent years (about 2 million ha annually), which itself is more than double the rate achieved at any time until 1974. Moreover, in view of budgetary and man-power constraints, the wisdom of devoting 90% to new projects and only 10% to modernization is open to question.
- 42) The strategy for irrigation development is of course a subject for the central government Ministry of Planning. There should however be in place what might be called a 'long-range conceptual unit' whose primary objectives would be to define future irrigation performance criteria in terms of expected needs, to analyze alternatives and requirements for meeting these performance criteria, and to determine hardware, software and training implications of various alternatives.

Need for a National Institute for Irrigation Management

- 43) The planning, design, construction and implementation of irrigation projects in India are matters dealt with by the separate States with limited guidance from the central government, mainly through the Central Water Commission (CWC). From the foregoing paragraphs, it can be seen that there are moreover at least nine major areas of irrigation management that are currently not receiving adequate attention at the national level, as follows:
Standards for feasibility studies leading to improved project planning (paras 13-18);
Monitoring (paras 24 and 25);
Institutional policies (paras 10 and 20);
Rapid appraisal of on-going projects (para 26);
Personnel policies (paras 27 and 28);
Training (paras 29-35);
Information exchange (paras 36 and 37);
Research coordination (paras 38-40); and
Macro planning (paras 41 and 42).
- 44) In conversations that the Study Team had with leading officials it was indicated that, although the Central Water Commission (CWC) would seem to be the suitable body which could be adapted to take on the tasks required, as presently constituted CWC has insufficient participation from pertinent disciplines other than engineering, i.e., economics, agriculture and sociology and that CWC is fully occupied with day-to-day tasks of reviewing and vetting mainly structure designs prepared by the State Irrigation Departments.

International Support

- 45) The officials with whom the Study Team spoke indicated a strong desire for international support, possibly through a national institute, yet to be clearly formulated. The support needed would be through 'action research' (see main text) and through advice and assistance to the national institute as provided by high-level experts in the various phases of irrigation management described above.

PAKISTAN

Background

- 46) Because of low rainfall and high temperature, irrigation in Pakistan is required for most agricultural production. Of the cropped area of 20 million ha, 70% or 14 million ha are irrigated, accounting for 90% of agricultural production. The Indus irrigation system, the largest in the world with a culturable command area of 12 million ha, makes up about 85% of the irrigated area of Pakistan.
- 47) A thumbnail sketch of the Indus system as given by an official of the Ministry of Agriculture is as follows: There are three major storage reservoirs, 19 barrages and headworks, 43 canal commands and 89,000 project outlets supplying farm watercourses having a total length of 485,000 km. This vast system was started in 1854. No drainage system was provided at that time since the watertable was 100 feet below the ground surface. Today the watertable has risen to within 10 feet of the surface in 7.5 million ha and within 5 feet of the surface in 2.5 million ha of which 1/3 is saline. During the previous several decades, 200,000 tubewells have been installed of which 180,000 are private with a capacity of about 1 cusec. The remaining wells are public with a capacity of 3 cusecs. The efficiency of the canal system is low - about 30% overall, not considering recovery of water by wells. Losses are about 25% in the main canal system, 35% in watercourses, and 10% on-farm. (The foregoing sketch does not agree in all particulars with other accounts especially in regard to losses, as described further below.)
- 48) An important constraint on the system is limited canal capacity, which almost uniformly amounts to 3-6 cusec per 1000 acres + 20% as compared with a usual design rate outside the subcontinent of 1 litre/sec/ha which is equivalent to 14 cusecs per 1000 acres. The present mode of operation of the canal systems is not conducive to conservation of water. The canals are generally run at full capacity during six months of the summer period and for 20 days a month during five months of winter period with one month allowed for shutdown for maintenance. The canals are occasionally run at less than full capacity but never at less than 75% capacity as there is fear that they would silt up if the discharge were made lower than this rate. The silt content is measured periodically at the barrages to govern operation. Lining the canals to increase their capacity would be difficult as the supply would have to be interrupted.

- 49) Despite the completion of two major storage dams (Mangla and Tarbela), the Indus system still lacks adequate reservoir capacity to enable full use of the flow of the Indus river basin so that a considerable portion still goes to the sea. Of the total flow of 152 million acre-feet, the flow to the sea is 39 million acre-feet. An optimization model which could be used to assist in operating the system has been under development for some years with the assistance of the World Bank but has not yet resulted in a practicable operating tool.
- 50) *Waterlogging and salinity* continue to be serious problems in the Indus valley. Current information is however somewhat conflicting. According to one version, the waterlogged area (depth to watertable 3 m or less) amounts to 7 million ha, 3.8 million in Punjab and 3.2 million in Sind. With respect to salt-affected area, according to the same origin, there are 8.8 million ha affected of which 5.1 million in Sind and 3.7 million in Punjab. A second version, based on a soil-salinity survey undertaken in the late 1970s covering an area of 9 million ha, found substantial improvement in surface and profile salinity as compared to information from a similar survey made in the early 1960s. Much of this improvement was attributed to the leaching effect of additional water supply from surface and groundwater delivered to the irrigated areas. The late 1970s survey determined that about 60% of the soils were salt free, 9% saline, 4% sodic and 26% saline sodic. Assuming by extrapolation that, of the 14 million ha irrigated area 40% is salt-affected, would give a figure of 5.6 million ha rather than 8.8 million ha (according to the first version).
- 51) *The SCARPs*: During the 60s and the 70s the so-called SCARP (Salinity Control and Reclamation Project) projects were undertaken with the basic concept being to install large public tubewells to lower the watertable to reduce waterlogging and at the same time develop additional water supply for irrigation. Covering a total of 7.6 million acres in areas varying in size from 30,000 acres to 1.8 million acres, there are 14 SCARPs in fresh groundwater areas involving 12,875 wells with a total capacity of 35,270 cusecs. In saline groundwater areas there are 6 additional SCARPs covering 1.9 million acres involving 2,016 wells with a total capacity of 3,598 cusecs; in these cases, the pumped water has limited use for irrigation. The SCARPs were designed and constructed by the Water and Power Development Authority (WAPDA) and are gradually being turned over to the Irrigation Department for operation and maintenance.
- 52) There are presently 178,000 tubewells in operation in the Indus valley of which 167,000 are private. The prime movers are primarily diesel (107,000), the remainder being electric driven. Public tubewells are generally of high capacity, 1.5 cusec or more. Concern was expressed to the Study Team regarding the lack of control of the private wells and the team heard on several occasions that many private wells have run dry.

- 53) A draft report 'Revised Action Program (RAP) for Irrigated Agriculture', May 1979, prepared by the Perspective Planning Division of WAPDA with financing by UNDP and with the World Bank as the Executing Agency, has pointed out that the public tubewells in the SCARPs are deteriorating and that adequate operation and maintenance would be easier to achieve if the number of smaller, private wells were expanded so as to gradually replace the public tubewells. The needed institutional arrangements have yet to be worked out including provisions for monitoring groundwater movements so that the private wells can be adequately supplied and so that waterlogging and salinity effects are mitigated.
- 54) *On-farm watercourses*: Chaks are subcommands below project outlets of which there are 89,000 as previously mentioned. The chaks vary in size from 200 to 700 acres (average about 450 acres) each covering about 20 to 50 farms. Flow to a chak first passes through a 'mogha' which is a contraction in the project outlet designed to pass an approximately constant proportion of the flow in the parent canals. Downstream of the mogha, there is a communal watercourse whose capacity is ordinarily between 1 to 3 cusecs. The distribution of water within a chak is by a time-rotation procedure called 'warabandi', with each farmer holding a specific time period in proportion to the size of his holding. Flow is diverted to various branches of the watercourse by constructing small earth dams at junctions, and to farms by cutting the banks of a watercourse. The boundaries of the chaks and the alignments of the communal watercourse are established by the Provincial Departments of Irrigation which also establish the official warabandi schedules.
- 55) The construction, operation and maintenance of the communal watercourse and other channels in the chak are the responsibility of the farmers. Because of poor farmer cooperation and inadequate technical assistance, many watercourses have deteriorated resulting in excessive delivery losses. As a result, farmers in the mid and tail reaches considerably less water than their planned share.
- 56) In 1973, WAPDA undertook a water management research project at the Mona Reclamation Experiment Station. The project was funded by USAID with expatriate research staff provided by Colorado State University and others. Further studies were carried out during preparation of the Revised Action Program (RAP) mentioned above. The Mona and the RAP studies reach some important conclusions with respect to water losses in the on-farm system as follows:
- a) about 40% of the water entering the watercourses is lost before reaching the field;
 - b) the loss was found to be 37% in Sind Province and 51% in Punjab province with little variation between the kharif and rabi season.
- Based on 1973-1974 irrigation deliveries, 40 million acre-feet more water will be required for delivery at the mogha to meet the crop water requirement than if efficiencies were increased to 67%, which could be attained through watercourse improvement. It was concluded as part of the RAP-study that the cost per acre-foot of water saved through watercourse improvement is only a fourth the cost of developing new water supplies.

- 57) Field application water efficiency is low causing excess percolation and surface-drainage losses. The mean loss as estimated from a 1978 survey was 56%, 41% and 43%, respectively, in areas served by public tubewells, by private tubewells and from canal systems (see 'On-Farm Water Management Project', Water Management Wing, Ministry of Food, Agriculture & Cooperatives; Islamabad, September 1981). The low field application efficiency is ascribed to unlevelled fields, lack of properly formed furrows and borders, and constant rate of supply of canal water irrespective of crop water demand.
- 58) *Future potential*: With the large irrigation system, favourable climate for year-round cropping and generally good soils, crop yields should be quite high in Pakistan. However, the prevailing constraints cause crop yields to be far below their potentials: wheat yields are 1.2 tons per ha, rice 1.5, cotton 0.3 and sugar-cane 40. Substantially increased yields as well as more double cropping are attainable through improved extension services and inputs of seeds, fertilizers, and pesticides; however, adequate water management is a prerequisite.
- 59) Pakistan's Fifth Five-year Plan (1978-1983) calls for a 6% annual rate of growth. Water supplies are to be increased by 11 million acre-feet or 2.4% per year leading to an estimated 4.8 million acre increase in the cropped area; a 'substantial beginning' is to be made to improve water management in the Indus system as well as on the farms; the flood protection program is to be completed; special attention is to be given to the expansion of irrigation by fractional tubewells. The agricultural sector is scheduled to receive \$642 million annually (about 22% of the planned total) of which \$342 million is for the water subsector. The water subsector allocation for the Fifth Five-year Plan is as follows:

	Allocation in million dollars	%
WAPDA		
Drainage reclamation	663	38.7
Irrigation	157	9.2
Reservoirs	66	3.9
Research	39	2.3
Federal Flood Commission	177	10.3
Tarbela, Indus Basin Plan (IBP)	229	13.4
Other Federal Agencies	96	5.6
Provincial Irrigation Depts.	295	16.6
	1712	100

With reference to the above tabulation, actual expenditures for Tarbela/IBP during fiscal years 1978-1979 and 1979-1980 generally equalled that allocated for the entire plan period and it would appear that expenditures for Tarbela & IBP will be roughly double that envisaged for the plan period which would mean sharp curtailment of public expenditure for non-Tarbela/IBP water sector projects and programs. As a result, government officials are indicating greater favour for new schemes that have low investment cost per acre and benefit many people. The financial situation thus further emphasizes the need for effective irrigation water management.

Needed Improvements in Main System Operation

- 60) Within the constraints of the system as now designed and under the operating system using warabandi, the system seems to be delivering water in an equitable basis (to farmers in proportion to their area) even though the water so delivered is less than what would be required if the farmers cultivated their entire holdings and if they double cropped. In areas with favourable groundwater conditions, the inadequate water quantity delivered by the canal system is being made up by pumping from wells.
- 61) Further major efforts to increase the total water available by making use of the flow still going to sea (39 million acre-feet), will require major expenditures as discussed above. There would seem nevertheless to be ways to increase water availability without major expenditure since the present water canal system, although operated in an equitable manner, may not be operated in an efficient manner. One way to improve efficiency might be to vary the flows in the canals since at the present time they are operated only at full capacity or not at all. To operate at part capacity will require more cross-regulators in the system, a subject that would need detailed study and design, with subdivision of the system into command areas (see discussion below). Such studies are included in a project now proposed for World Bank financing. Other methods would be to go in for crop zoning and staggering, including rotation of water supply-between adjacent areas. If the system had better telecommunications it might be possible to operate the system more efficiently so as to conserve water when rains occur.
- 62) Conversations that the Study Team had with various officials indicated widely varying perceptions regarding the problems of operating the systems. In general, engineers with the Provincial Irrigation Departments who are presently in direct charge don't seem to feel that there are many problems. They say that since the storage dams have been completed, they run the canals full at all times except for fixed closure dates for maintenance (in January), and that the farmers get delivery on time without problems. Other officials have a remarkably different perception and that is why some of the expedients regarding operation of the systems, described above, are receiving serious consideration and will be subject to study in the near future.
- 63) One operating engineer did say that, since it realized that the capacity of the canals is too low, the duration of flow in the minor canals should be increased in order to make up for the lack of capacity. He said that the canals run full during the six summer months and 20 days per month for five winter months. Also that changes in operation of the canals in the upstream systems (in the Punjab) might have to be changed, thereby increasing water availability to the Sind, in the lower part of the Indus valley system.
- 64) The Provincial Irrigation Department's staff pointed out that funds for operation and maintenance are seriously inadequate; in constant terms, these are perhaps no more than 20% of what was available five years ago. As a result, what often happens is that accumulated operation and maintenance work, instead of being provided for in current budgets, are shifted to development budgets.

- 65) Some technicians say that improving efficiency of the canal system is not urgent in Pakistan since most of the seepage goes to the groundwater where it can be recovered through pumping. Although much of this may be true, the growing cost of energy and the capital investment required for pumping facilities needs to be taken into account. According to WAPDA, 25% of the diverted surface flows are lost in the distribution system above the mogha through deep percolation and evaporation (see 'Revised Action Programme for Irrigated Agriculture').
- 66) *Command Area Approach:* In order to deal in a comprehensive manner with canal system management, it is now thought that specific portions of the canal system ('canal commands') need to be selected for development planning and implementation. WAPDA and its consultants are presently preparing a feasibility study for several such selective canal commands varying in size from 50,000 to 100,000 acres. According to the terms of reference for the study which the Study Team received, not only would operation of the canal system be determined but also other water control aspects such as drainage and conjunctive use of groundwater and surface water, adequacy of farm-to-market roads, requirements for tubewell electrification, needs for public sector support and private sector participation in watercourse improvements and tubewell installation through credit, improved cropping patterns and in general a complete agricultural plan for more intensive development of the command area. Priority would be given to areas where major agricultural constraints can be removed at relatively low cost per acre. For example, in the selected areas, the watertable should generally be lower than 5 feet and major improvements to the distribution system should not be required; the areas should be generally free of sodic soils; and land ownership and tenancy should be comparable to the general pattern for the province with priority given to sub-project areas where the majority of benefits will accrue to farm holdings of 12.5 acres or less. Funds for the studies will be available from an existing IDA credit. The total area to be studied will be about 1 million acres. The study would be carried out during calendar year 1982.

Waterlogging and Salinity

- 67) Although waterlogging and salinity problems are apparently not getting worse, the situation requires constant vigilance and monitoring so that this does not happen. Moreover, major benefits could be obtained if ways to eliminate the existing waterlogging and salinity could be accomplished in an economic manner. Further groundwater development through conjunctive use, already accomplished in a substantial manner, needs to be continued. There is concern that, since adequate monitoring of private wells has not been carried out, there are dangers that some of these wells may either become saline or run out of water. The questions are quite complicated technically and, although technologies are available for both monitoring and analysis, they have still to be applied.

- 01 -
- 68) A major constraint to further groundwater development is the availability of energy, whether through electricity distribution or by use of fossil fuels.
 - 69) Specific problems needing research include: the extent to which waterlogging and salinity control is needed to improve the cotton crop and how to eliminate sodic conditions in an economical manner.

Needed Improvement in On-Farm Systems

- 70) 'Action research' to improve on-farm water management has been underway in Pakistan since 1973, as described above. Currently, three programmes are either underway or about to start. The first programme, 1976-83, which has USAID support in the amount of \$32 million, involves improvement of 1500 watercourses and precision land levelling in 425,000 acres. The second programme, which is about to start with Asian Development Bank financing (\$37 million), involves improvement of 1250 watercourses and installation of 950 private tubewells. The third programme, also just about to start, has IDA and IFAD financing to the extent of \$53 million with additional domestic financing amounting to \$59 million (equivalent); 2,065 watercourses will be improved and 16,500 watercourses will be renovated and precision land levelling will be carried out on a demonstration basis in 37,000 acres.
- 71) *Extent of targets achieved:* Targets under the first programme have been achieved only to the extent of one third with respect to the watercourse improvements and only about 10% with respect to precision land levelling. The reasons given for the shortfall includes shortage of graduate-level personnel, inadequate training facilities at three training institutes that were established at Lahore, Hyderabad and Peshawar, deterioration of improved watercourses due to inadequate maintenance by farmers, shortage of skilled extension workers capable of extending advisory assistance in irrigated agriculture and inadequate funds for procurement of required materials.
- 72) The first programme has been under execution by the Ministry of Food, Agriculture and Cooperatives through a Federal Water Management Cell with implementation by On-Farm Water Management Directorates within each of the Provincial Departments of Agriculture. This has seemed to have worked satisfactorily except for insufficient involvement of farmers in Water Users Associations and, as indicated above, lack of adequately trained extension personnel (Village Level Workers).
- 73) It is noteworthy that some of the methods and designs for improvement of watercourse development in Pakistan could well have application in other countries, especially India. The two features in particular that are noteworthy are: a) 'Pucca nuccas' which include pre-cast concrete panels and circular covers of about 12" diameter which can be easily handled and which enable rapid opening or closing of watercourses and farm-channel off-takes and; b) procedures for reconstruction of earth channels in stages so as to ensure ample stripping of organic materials and placement of clean, compacted soil in a controlled manner.

- 74) *Rethinking needed on land levelling:* The inability to make much progress with precision land levelling requires rethinking of this aspect of the programme which involves development of an intermediate, less precise solution but one that still gives adequate benefits. Action research concerning land levelling should actually include proper cultivation practices suitable for irrigated agriculture. The method of irrigation universally practiced is flood irrigation without borders and without furrows. As already mentioned, this causes considerable lowering of water-application efficiency and may also be detrimental to plants in not having adequate drainage during monsoon rainfalls which sometimes are heavy. Also plants may not get sufficient aeration. Part of the problem, as in India, is lack of suitable implements that can be drawn by bullocks in order to form borders and furrows. The University of Agriculture at Faisalabad is already embarked on studies of furrow-bed land forming which they think could result in a 35% saving in water.
- 75) *Roads:* With regard to farm-to-market roads, field staff with whom the Study Team spoke thought that lack of such roads was a medium and long-term constraint and that roads should be planned in conjunction with improvement of distributary and minor canals and even watercourses, but that this might be difficult to achieve since roads were under jurisdiction of another provincial government department.

Changes in Institutional Arrangements

- 76) The Provincial Irrigation Departments are presently oriented to construction and operation and have little capability for planning, whether for new projects or for improvement of existing ones. It will be the intention under the command area approach described above to develop a continuing capability for this purpose. Actually, there is need for provincial and canal command coordination of all agricultural and irrigation inputs. The Revised Action Programme for Irrigated Agriculture outlines the proposed arrangements. It calls for the establishment of an Additional Chief Secretary for Agricultural Production, and Command Area Management Cells to integrate appropriate programmes of the Provincial Irrigation and Agriculture Departments. The latter recommendation is of particular interest since most planning is presently carried out by WAPDA, not by the Provincial Irrigation Departments. This appears to be a defect since it is thought that the actual rehabilitation will be carried out by the Departments, not WAPDA.

Manpower Planning

- 77) *Personnel policies:* Several leading Pakistani officials mentioned that excess mobility of personnel is a problem.
- 78) *Training:* To deal with on-farm water management, there are three Water Management and Research Institutes at Lahore, Hyderabad and Peshawar and additional training and research institutes are planned. Trainees thus far number 1600 government officials, 500 farmers, and 4000 tractor operators for land levelling.

- 79) In order to carry out the command area programme described above will require additional important training efforts, in all areas of water management, for Provincial Agriculture and Irrigation officials. Training will have to cover determination of crop water requirements and methods of operating the irrigation system to better meet such requirements. Computer software programmes for irrigation deliveries and scheduling will have to be developed. Attention will thus have to be given to further development of training facilities, either at the three training centres mentioned, or at other locations.
- 80) At university level, the so-called Centre of Excellence in Water Resources Engineering in Lahore was established in 1977. Refresher courses are given in cooperation with WAPDA on project preparation and there are water management courses for Ministry of Agriculture personnel. According to the Director, the faculty was planned to number 22 but only 10 have been recruited so far. Further study is needed to determine the proper role of the Centre of Excellence in the training of university-level and post-graduate staff in water management.
- 81) There are courses in agricultural engineering at the University of Faisalabad, but they offer only a BS not an MS degree.
- 82) Officials of USAID indicated to the Study Team that that agency would like to consider how best to assist research and training efforts.
- 83) It seems clear that a strong national institute for water management is needed to assist in guiding manpower planning with respect to both personnel policies and training.

Research

- 84) The Pakistan Agriculture Research Council (PARC) is an autonomous agency now three years old. Staff working for PARC do not follow the normal civil service regulations. Funding for various research topics to be undertaken by PARC appears to be available from USAID and from IDA. PARC intends to establish a research farm 1,400 acres in extent located six miles from Islamabad. It will contain a block of precision-levelled land. PARC intends to create a social science division which will be multidisciplinary. The Director of PARC said that they wish to research topics involved in water management below, not above, the mogha. He said that WAPDA must deal with the larger works because of the power component involved in the planning and development of such works.
- 85) Pakistani officials feel that a major research topic to be addressed is how to deal with waterlogging and salinity on a large scale. For this purpose some negotiations have already proceeded with the government of Italy. What would seem necessary to work out with respect to a research programme for waterlogging and salinity would be how to interface with concurrent efforts in related aspects of water control such as increased storage through additional reservoirs, conjunctive use of groundwater and surface water, and improved operation of the canal system; in other words, waterlogging and salinity should not be studied in isolation.

- 86) Another research effort going on since several years is that of the Irrigation, Drainage and Flood Control Research Council of the Ministry of Science and Technology which is sponsoring a Drainage and Reclamation Institute of Pakistan (DRIP) effort at Hyderabad involving a staff of 55 professionals which is supported by the Netherlands.
- 87) Other specific topics for research that were mentioned to the Study Team include: how to deal with the 'regime canals' in order to avoid excess of siltation or scouring; farming systems under present water-control constraints including gradual modifications as some of these constraints are removed; and plant stress under water shortage.
- 88) As in the case of manpower planning, there is a need for a national institute dealing with irrigation water management to guide, control and monitor research.

Information Exchange

- 89) Various officials complained about the flood of information regarding irrigation water management that is available on a world scale and that as a result many officials and technicians are confused since it is difficult for them to determine what part of the information is pertinent and what is not. To deal with this problem, suggestions as proposed earlier in this annex for India should be considered.

Long-Range Planning

- 90) Since the Revised Action Programme of WAPDA was issued in 1979, work has continued but on a greatly reduced basis. The official in charge of planning for WAPDA said that this reduction in effort is serious since the type of planning that was carried out in preparing the Revised Action Programme is of such a nature that, once such a perspective plan has been completed, it must then be continuously updated; however, adequate staff is not available for such work. The Revised Action Programme prepared in 1979 is actually the third such effort carried out in a space of about 15 years. For all three efforts, there was a major input of expatriate staff which has now departed but Pakistani staff able to carry on with the studies needed for continuous updating need training and technical assistance.
- 91) Another need is for a long-range conceptual planning unit whose primary objectives would be to define future irrigation performance criteria, and to determine hardware, software and training implications of the various alternatives.

Need for a National Institute for Irrigation Management

- 92) From the foregoing paragraphs, it can be seen that there are at least six major areas of irrigation management that are currently not receiving adequate attention at the national level, as follows:

- Improvement in main system operation (paras 61-66);
Monitoring of private wells (para 67);
Improved institutional arrangements (para 76);
Improved training (para 78-83);
Improved coordination and monitoring of research (paras 84-88); and
Continued efforts in long-range planning (paras 90 and 91).
- 93) To provide guidance and direction in these areas, a National Institute for Irrigation Management, similar to the one suggested for India, would seem desirable.

EGYPT

Background

- 94) Agriculture continues to be the largest sector of the Egyptian economy, contributing about 23% of GDP and employing about 40% of the labour force. While the country's overall rate of economic growth has accelerated since the mid-1970s, the expansion of agricultural output has averaged only about 2% a year, substantially below the rate of population growth and income-induced increases in demand.
- 95) Given its climatic characteristics, geography, and natural resource base, Egyptian agriculture has for several millenia been inextricably tied to irrigation. In the last century or so there has been considerable development of irrigation infrastructure which has permitted the introduction of intensive cropping techniques and use of progressively more modern inputs in an irrigated area of 5.8 million Feddans (2.4 million ha) - the so-called 'Old Lands'. The culmination of this infrastructural growth was the construction of the monumental Aswan High Dam, commissioned in 1969. It eliminated widely fluctuating Nile flows and enabled perennial year-round irrigation of the Old Lands.

The Old-New Lands

- 96) The High Dam was accompanied by an ambitious programme to extend the irrigated area by over 900,000 Feddans (380,000 ha) by the mid-70s in the so-called 'Old-New Lands'. This programme was rather unsuccessful since about a quarter of this area is only marginally productive while the balance, for the most part, is producing crops at sub-marginal levels or has been abandoned. As a result, the Old-New Lands, representing about 15% of the net irrigable area, produce only 3% of the agricultural GDP. Despite the current low output, it seems likely that the productivity of the Old-New Lands could be increased at a far lower cost than that of reclaiming entirely new areas in the 'New-New Lands' (described below). Especially on the western edge of the Delta, there are large areas in the Old-New Lands which require 'topping-up' investment, in the form of the provision of drainage or the improvement of existing drainage at either the project level or on-farm, the renovation of pumping stations and the rebuilding of water-control structures. The Government is currently attempting to turn some of these earlier projects into joint ventures with private companies

or to settle them with smallholders, as in the case of the old so-called 'Mechanized Farm', whose rehabilitation is being funded by IFAD under the West Beheira Project.

- 97) One reason for delay in development of the Old-New Lands appears to be a diffusion of responsibility among ministries for their upkeep and the lack of clearly defined goals, both financial and productive, by which the managements of the public sector companies could be judged. Some of the companies come under the Ministry of Agriculture, others under the Ministry of Land Reclamation while the Ministry of Irrigation is responsible for water supply and the maintenance of the irrigation system.

On-Farm Water Distribution in the Old Lands

- 98) On-farm water distribution starts at the mouth of the farm header ditch (commonly called 'meska'), which generally serves an area of 24-400 feddans (10-160 ha). From that point on the farmer is responsible, with little or no institutional support, for management of the water and for maintenance of the farm ditches that vary in length from 150 to 400 m per feddan of irrigated area. As the public system provides water to the major portion of Old Lands about half a meter or more below the general ground level, water has to be lifted by the farmer. This is generally accomplished by the sakia, a water wheel worked by animal power, though the use of pumps is expanding.
- 99) Inherent in this system are application inefficiencies as well as considerable costs to the farmers. Except in period of keen demand, the cultivator prefers to lift water from the canals only during the daytime. The costs and penalties associated with this practice include handling water wasted to the drainage system, the loss of productivity and increasing incidence of waterlogging. The fact that the farmers, during the rotational turn of their irrigation channel, are free to lift water as and when they like often leads to an inequitable distribution along the channel. Studies show that water per feddan decreases with the distance from the channel intake. In the Old-New Lands of the West Delta, the use of water, pumped to various heights currently approaching 50 m, is even more wasteful because of the interaction amongst some of the above practices, basin irrigation, and the sandy nature of the soils. Overall water efficiency in some of these areas is only about 25%, as compared to nearly 60% in the Old Lands.
- 100) *Current 'action research'*: A common observation by the Ministry of Irrigation (MOI) is that farmers over-irrigate. The data indicates that more water is distributed than necessary apart from the three peak months. A considerable volume is used for pre-irrigation for animal power (fodder) cultivation, and there is a possibility of reducing releases in October and May as tractor mechanized cultivations increase. The whole question of on-farm water management is being studied by the Water Research Centre (WRC) of MOI in the Egyptian Water Use and Management Project (EWUP) being carried out with assistance from Colorado State University (CSU). Among other things, these studies show that the irrigation rotation (generally 7 days on and 7 days off in summer) constrains yields due to moisture stress, and contributes to overwatering since farmers over-

irrigate in the 'on' period to compensate for the 'off' period. Water could be saved and plant moisture stress could be reduced by shortening the duration of on and off periods in the canal rotation. There is also considerable wastage to drains at night when farmers do not commonly irrigate due to the problems of supervising at night the lifting of water by animal-driven sakias. The EWUP Project is also evaluating the inequitable distribution of water among cultivators on a channel - the so-called 'tailender' problem. Apart from the technical results, the project is providing unique multidisciplinary 'field' training for Egyptian technicians.

Modernization of the Intermediate System

- 101) Besides better on-farm water distribution, the 'intermediate system' (mainly minor canals upstream of the meska) will need improvement and modernization. As water grows increasingly scarce, improvements leading to more efficient water use might well include one or more of the following:

- raising the meska for gravity flow;
- lining the meska, particularly in sandy soils;
- pumping from the meska to the field;
- pumping from the minor canal to the meska;
- raising the minor canal;
- improving the control structures on the minor, or more senior, canals;
- on-farm drainage and/or more senior drains;
- farmer associations/farmer training.

The strategy of such upgrading would be to work from the farm field outwards, doing all that was necessary to achieve farm-level control to raise yields. Given that the 'tailender' problem is clearly of less importance in some areas than in others, and that the shortage of water in some commands in peak requirement periods varies from place to place, such improvement might already bring sufficient benefits in some areas to justify them under current cropping patterns. There is little research evidence as yet to make preliminary judgements as to which are the priority areas and whether such improvements would increase agricultural production sufficiently to cover the costs involved.

- 102) Although cropping intensity is already nearly 200%, it could move to still higher intensities with more rapidly maturing crop varieties and alternative forage systems for improved livestock. This sort of qualitative improvement, however, would require significant change in policies and practices now inhibiting appropriate incentives. A start has been made on collecting the needed evidence. Three canal commands have been analyzed by the so-called 'Water Master Plan Organization' which plans to complete an analysis of water distribution and use on the remaining canal commands.

Modernization of the Main System

- 103) The area commanded (2.8 million ha in the Old Lands and the Old-New Lands) is served by a network of canals and irrigation channels, the total length of which has increased from 25,000 km in 1965 to over 30,000 km in 1980. The historic process of planning and design have determined the system's basic technology and its means of operation. The main limitations include: limited control in water

delivery system, which operates by channel levels rather than by flow measurements; command area water duty based on past observed diversions rather than matching crop needs; supply of water to the distribution channels on a rotation system that alternates on-off time periods, varying seasonally with cropping patterns; and the need for most farmers to lift water, rather than have water provided by gravity flow. Aggravating the combined effect of these system characteristics is a huge backlog of deferred maintenance. Studies also show that available water is not always equitably distributed. Also some canals, such as Bahr Yousaf and Bahr Saghir, have inadequate capacity to deliver peak period flow demand.

- 104) Although it appears that there is more or less enough water to support the existing agricultural production on the Old Lands under present conditions, future increases in production will be critically dependent on adequate supplies in the peak months and additional water will be required. It is not known whether canal capacity is sufficient to deliver the increased peak volumes. It is thought, however, that deliveries in the primary and secondary canals could be increased by 10-20% without problems, but that some of the structures would have to be rehabilitated to achieve this goal. The tertiary system would however need no physical modification and deliveries could be increased by lengthening the 'on' period in the canal rotation.
- 105) In sum, the main-canal system capability is not conducive to providing the Old Lands the correct amount of water to meet crop evapotranspiration needs; there is excess at time and at places, and deficiencies at others. The basic design, operation and inadequate maintenance place an upper limit on the performance levels which are achievable. The system has long supported an impressive effort in irrigated agriculture, but is increasingly proving a constraint for the needs of modern and future agriculture.

Operating the System

- 106) Lake Nasser water is released according to a tentative schedule prepared prior to the irrigation season. The system for allocating water to various uses and for accounting losses and gains is derived primarily from experience. For agricultural use the water is prorated according to seasonal estimates of effective irrigable area and general water-use values and then adjusted for overall climate, soils, sugar cane and rice. The water requirements are not adjusted for micro-climatic factors.
- 107) A minimum release of 6 million m³ per day is made for navigation and domestic use except during the canal closure period in January¹ when daily minimum releases of 80.7 million m³ for hydro production are needed. Water distribution within a canal command is essentially controlled by the pattern of water supply diverted or pumped into the canal. The main water distribution objective at the regional level is to try to maintain equity of supply throughout the service area, especially to the tail reaches during periods of high demand. Together with the limited control and lack of flexibility within the canal system, however, this limits the scope for response to variations in demand.

¹ Closed for cleaning.

- 108) The Ministry of Irrigation traditionally prepared information on system water requirements and water use by quantifying gross inflows and outflows to and from cropped areas. Gross averages can however lead to inaccurate information and certainly incorrect conclusions for a specific area. There are varying estimates on what constitutes gross, net irrigable, irrigated and harvested areas for the entire Nile Basin or within it for a given canal command. The problems are greater in the Delta than in Upper Egypt. Data on drains emptying into the canals are not available, and the outflows from the Nile Delta are not fully tabulated. Precise information thus is lacking about how water is distributed and used within the overall system.
- 109) Although available data (crop consumption use, water duties, actual deliveries, etc.) indicate that overall water supplies are sufficient on an annual basis, except possibly in Fayoum canal command, when monthly deliveries are taken into account, a different picture emerges. A shortfall is indicated of up to 25% or 1.5 billion m³ of the consumptive use requirement, affecting nearly 50% of the irrigated area during the peak water demand season (June, July, August). However, the observed effect on crops of water shortages during the peak season does not support a 25% shortfall in crop requirements since the existing level of yields could not be obtained if the crops were actually 25% short. Some stress is observed in the peak growing season, nevertheless, particularly at the tail end of minor canals and the end of the meska. Of several possible explanations for the sharp difference between theoretical and actual irrigation requirements, the three most likely are:
- a) crops make up their requirements from the high watertable. This is probably for cotton, which is deep rooted, and could be important for other crops through upward capillary movement of moisture through the soil;
 - b) factors other than water supply are limiting crop yield, e.g., low plant population in maize due to stripping of leaves and removal of plants to feed livestock; and
 - c) the effect of urbanization (see below) and the loss of agricultural land are not fully reflected in the agricultural statistics, with the result that crop areas are over estimated and the crops receive approximately enough water even though the irrigation water duty is underestimated.
- 110) With the information available at present it is hard to say whether capital investment will be required to remedy this situation, for several reasons. First, of some 50 canal commands, detailed water balances have been prepared for only three. Data for the remaining commands are based on rough balances only. It would appear possible to modify the operation of the High Dam to increase releases from June through August to make good the estimated shortfall of about 1.5 billion m³ but without firmer evidence it may be better to conserve water in Lake Nasser for peak hydro-electric generation in the winter. Full analysis of the available data is obviously a high priority, as is completion of the Nemec irrigation distribution model.¹ Also of interest is the possibility of reducing releases in October and May as tractor mechanized cultivations increase. A considerable volume of water currently is used for pre-irrigation for animal power (fodder) cultivation.

¹ 'A Mathematical Model of the Irrigation System in Egypt', James G. Nemec, 1976.

Drainage System

- 111) The drainage system for evacuating surplus water from cultivated lands comprises some 17,500 km of open drains serving more than five million feddans (2.1 million ha) and buried tube drains installed in an area of about 1.8 million feddans (0.8 million ha). The drainage operation requires pumping stations at numerous locations; their number has increased from 52 in 1964/65 to 96 in 1980.
- 112) In the Old Lands serviced only by open drains, the system is neither complete nor efficient. While by 1965 some five million feddans were provided with main and branch drains, farmers refrained from providing field drains mainly because they could not afford to lose 10-15% of their land to these channels. The design depth of water level in open drains, initially fixed at 1.5 m below the adjacent ground level, was increased to 2.5 m in 1940. As a large number of drains still operate as originally constructed, the restrictive design and absence of field drains limit their capability to have significant effect on watertable. The huge backlog of deferred maintenance and profuse growth of weeds in most of the drains have reduced their efficiency further.
- 113) Decades of perennial irrigation, aggravated by wasteful use of surplus waters from the High Dam, have led to a rise in the watertable to the extent that potential crop yields in the greater part of non-tiled areas have been constrained from slightly to severely. Where tile drains have been installed and are maintained properly, analyses of crop data indicate yield increases of 12-16% resulting from improved drainage. Encouraged by these results, the government plans to provide tile drainage in most of the rest of the Old Lands. At the present rate of progress it would take another five years to complete the more than one million feddans still undrained within on-going projects and a further ten years to drain the remaining area in the Old Lands, let alone take care of the problem in the Old New Lands.

The New-New Lands

- 114) A major constraint to increasing agricultural production in the Old Lands is the large and accelerating loss of irrigated crop land to non-agricultural, mainly urban uses. The amounts lost over the 17 years ending 1978 were 470,000 feddans, or about 940,000 feddans of annual crops, equivalent to about 8% of the cropped area. The annual rate of loss appears to be accelerating since estimates show that perhaps 35,000-60,000 feddans were lost annually in 1977-80. If these rates continue, some half a million feddans - more or less equivalent to one million feddans of annual crops - will have disappeared by the end of the century. Thus the agricultural sector, on a reduced Old Lands base, must add some 16% (1/6) to current total output over the next two decades just to offset this loss.
- 115) Partly to offset the loss of land to urbanization but also for other reasons, Egypt plans further reclamation in the so-called 'New-New Lands' covering perhaps 600,000 ha located mainly in the Nile Delta bordering the Mediterranean or in Sinai. Since most of these lands have soils which are difficult to manage or are at elevations requiring relatively high pumping lifts and in view of

the limited success achieved in the Old-New Lands, a very high premium is placed on adequate project selection, analysis, design and implementation.

MEXICO

- 116) Mexico irrigates almost 5.5 million ha with yields and water-use efficiencies generally above world-wide averages. Water is, however, in short supply in most of the country. As a result of rapid urbanization, irrigation in the Central Plateau will have to be restricted and/or water-use efficiency will have to be substantially increased. On the Pacific Coast, expansion of the irrigated area is still possible although of high cost per ha. Mexico plans to double the area irrigated by the year 2000, to concurrently rehabilitate and drain about a fourth of the area presently irrigated and to further improve water-use efficiency mainly through land levelling. For these purposes, Mexico plans to spend \$3 billion per year 1982-90 and \$4 billion per year 1990-2000 (1980 dollars).
- 117) In the Gulf Coast, Mexico has an extensive tropical-humid zone with relatively good soils in perhaps 4 million ha. The development problems here concern drainage and flood control (supplemental irrigation would come in later), land settlement, farmers' organization, and adoption of appropriate technological packages and farming systems. Several pilot projects are underway to indicate solutions of these problems.
- 118) During discussions with the Study Team, Mexican officials stated they have welcomed international support in the past and would further welcome it in the future particularly as regards ways to further increase water-use efficiency, avoid salinity and develop appropriate farming systems with water control in the tropical-humid zone (thus far they have little experience in this kind of environment).
- 119) With respect to water-use efficiency, which now averages about 40 to 50% overall, Mexican officials are developing and adapting trickle systems for high-value crops but think that the biggest impact will come from incentives to farmers to conserve water on the much more extensive medium-value crops. The officials feel higher water charges will have only limited effect and would rather like to have ideas and results of research on other ways such as rotational water supply and possibly some sort of schemes for rationing of water.

SUDAN

- 120) The Gezira scheme, 900,000 ha in extent and in operation over 50 years, suffers from major deferred maintenance and price policies that discourage farmers from growing the most valuable crop: cotton, the output of which has been steadily decreasing. Mechanical-cultivation equipment operated by the Gezira Board also suffers from inadequate maintenance and lack of spare parts. On-farm water management is less than optimum causing low water-use efficiencies. Improved irrigation management is needed for both 'water management' and 'enterprise-type management'. A group of consultants in cooperation with Sudanese officials is preparing a rehabilitation plan for Gezira.

- 121) Another large scheme, Rahad, which is still under construction, will develop similar problems, unless remedial actions similar to those for Gezira are undertaken.

PHILIPPINES

- 122) Irrigation has been practiced for centuries but based on run-of-river diversions with single cropping of rice. The first storage dam, Upper Pampanga, completed 1969, enabled double cropping of rice for the first time. The areas served by this dam, 78,000 ha, give good yields but the project has not fully matured as yet so that adjustments have still to be made to ensure fully equitable distribution and better drainage especially in lower portions of the canal command. Another major dam, Magat, in Northern Luzon is about 1/2 built and will serve 100,000 ha.
- 123) About 470,000 ha are served by national systems under the National Irrigation Administration (NIA) while some 550,000 ha are small communal systems operated by farm communities. Many of the small systems are now being upgraded through joint efforts of the communals and NIA. This program seems to be going well but will need monitoring to ensure continued operation and maintenance of up-graded schemes.
- 124) Largely as a result of its irrigation program, the country is now self-sufficient in rice (the main crop). The area, yield and production of rice increased from 1970 to 1979 as follows:

	1970	1979
Area (1000 ha)	3,115	3,470
Yield (tons/ha)	1.68	2.07
Production (1000 tons)	5,200	7,200

- 125) Despite this good record, operation and maintenance of the irrigation systems is seriously deficient so that half of the national systems are in need of rehabilitation. To develop manpower to take on the task of better operation and maintenance of both main and on-farm systems, NIA in 1975 started training programs centered on the Upper Pampanga system and, later on, an input-output monitoring program for agricultural development plans in newly developed or rehabilitated systems. Both programs deal with critically felt needs and hopefully will continue to have priority and high-level support. In addition, a higher budgetary allocation to operation and maintenance, and to rehabilitation (rather than construction of new projects) would seem desirable.
- 126) A number of management innovations in The Philippines deserve special mention.

Main System Management

- 127) Joint action research by NIA and IRRI has been undertaken since the early 1970s (see e.g. Bhuiyan 1980, Early 1980, and IRRI Annual Reports and Research Highlights). Redistribution of water from head

reaches to tailends, coupled with increased responsiveness of water supply to rainfall (reducing flooding), and increased reliability of supply, led to increases in production for all farmers (Valera and Wickham 1976; Early 1980). This included those in the head reaches, although the gains in the tails were largest. This work was conducted in the Lower Talavera and Upper Pampanga Systems. The Upper Pampanga Integrated Irrigation System (UPRIIS) also has a monitoring system with an annual monitoring report produced by consultants. UPRIIS system are well developed, with radio communications and regular reporting of local conditions to a coordinating centre. The management innovations have not yet spread widely in The Philippines, although they have been tried. One reason may be that extensive discussions with farmers before changes were introduced may account for the success of the action research, and may not have been adequately replicated.

On-Farm Development

- 128) On-farm (below the outlet) development work of NIA and IRRI has involved farmer participation, and comparisons of layouts of paddy fields as prepared by different methods, including by farmers themselves. The conclusion has been that farmers' layouts are generally superior to those of design engineers using contour maps. Three procedures have been found efficient and are now variously practiced:
- 1) involvement of farmers in appraisal and design from the outset. This includes farmers and engineers walking together through the area. The 'participation' in which a design prepared by engineers is presented to farmers for their comments or objections is not followed.
 - 2) farmers are taught how to map their paddies, and prepare maps using simple measuring methods and a 'back board'.
 - 3) a 'custom fit' technique is used in design starting from the tail of the outlet command area, and working backwards up towards the outlet.

Communals and Participation

- 129) A highly participatory approach has been developed, and is now being extended, for the rehabilitation of small communal irrigation systems. This includes:
- a) community organizers. Specially trained community organizers live and work in the comunals for some months before any works are undertaken.
 - b) profiles. Socio-technical profiles of comunals are prepared through methods of rapid appraisal (de los Reyes, n.d.).
 - c) process documentation. In some cases, detailed records are kept of the process of participation, to generate practical insights, and to provide training materials for community organizers and engineers.
 - d) initiative and control lie with the community. For example, the community leader signs purchase orders, and a community committee checks the quality of materials to be used in construction.
- The experience with this approach (Korten 1981) has been favourable. A longer period is required before construction begins, but after construction the community has a sense of ownership and responsibility for the work, in contrast with earlier experiences without

participation. The next stages, when attention shifts to the management of the additional water provided by rehabilitation and new construction, will repay careful monitoring.

Institutional Change

- 130) NIA has a long history of institutional innovation. It has developed an openness to collaborative learning - from farmers, and from research - which may have been a precondition for the approaches listed above. Some features deserve to be noted when considering replication:
- a) stability in post. In contrast with many irrigation organizations, NIA staff are usually in the same post for several years at a time. They do not appear to be subject to transfers as a result of pressures from outside the organization.
 - b) consultative committees. Two committees, chaired by NIA but with participation from other organizations (University of Philippines), Los Banos, the Institute of Philippine Culture, the Asian Institute of Management, IRRI, the Ford Foundation, and others), have been influential in developing new approaches. The two committees are ISMARC (the Irrigation Systems Management Research Committee) and CIC (the Communsals Irrigation Committee).
 - c) flexible funding to NIA from the Ford Foundation has been a key factor in permitting room for manoeuvre within the agency to support new approaches.
 - d) long-term relationships. Those engaged, both within NIA and outside, have worked together over the years, developing mutual understanding and trust. None of the changes has come about quickly. The stability in post and personal attitudes of senior NIA staff has been a critical factor in success.

The Future

- 131) Irrigation in The Philippines is set on a course which promises further innovations. NIA, with collaborating researchers, is continuing to work on farmer organization and participation on larger systems, on communals management, and on monitoring and main system management. It has a business-management oriented Corporate Plan for 1981-1990 (NIA 1981). It proposes to set up a Systems Performance Evaluation Team to assess systems' operation, maintenance, financial, agricultural and other activities. It also has a consulting wing, NIACONSULT.

The opportunities for people from other countries to visit The Philippines and learn systematically from the experiences, both positive and negative, of these various approaches, are not yet streamlined. In the view of the Study Team, there is enough of value to justify a special effort, either on the part of NIA, or in collaboration with an outside agency, to organize visits, both to minimize demands on the time of NIA staff, and to make the visits efficient.

NIA is already undertaking training for personnel from other countries. At the time of the Study Team's visit, engineers from Sri Lanka were taking part in a course at Munoz, on the UPRIIS. The Study Team received a proposal from SEARCA (the South East Asian Regional Centre for Graduate Study and Research in Agriculture),

which is headquartered at the Campus of the University of The Philippines, Los Banos, for the establishment of a Centre for Irrigation Management in Southeast Asia.

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PERU

- 132) The Peruvian desert on the Pacific Coast was irrigated even during the time of the Incas, the total area involved being almost a million ha. Water was obtained from steep rivers draining the west slope of the Andes.
- 133) The major crop in the 20th century has been sugar cane of which Peru used to be a major exporter. A combination of growing salinity and disruptions in sugarcane-plantation management caused by land-reform adjustments has caused drops in output during the past two decades. A rehabilitation program covering six of the coastal valleys has been underway for several years and shows promise.
- 134) With the exception of the Chira-Piura, Tinajones and Jequetepeque projects in the north there are hardly any storage-dam possibilities on the rivers draining the Andean west slope and Peru is therefore undertaking trans-Andean tunneling on a large scale but at high cost in the so-called Majes scheme. The soils served are however of marginal quality. A major problem is how to allocate funds and manpower for rehabilitation of the coastal valleys (also Chira-Piura) vs. completion of Majes. Other trans-Andean schemes in progress are Olmos, Mantero River and Pampus River.

SENEGAL

- 135) Two different types of irrigation systems are encountered in Senegal:

- grands périmètres irrigués: roughly 100,000 ha under central management in which the responsibility for construction, operation and maintenance as well as for part of the agricultural operation is with a specially created government organization (Société d'Interventions);
- petits périmètres villageois: roughly 3,000 ha in which the government assists local farmers organizations on a village level to implement irrigation projects varying in size between 10-50 ha on the average. Construction, operation and maintenance as well as all farming operations are the responsibility of the farmer or farmers organization.

136) Insufficient maintenance as a result of lack of maintenance funds is a serious problem in centrally managed irrigation systems. Systems which are designed, may be technically sound, but with a degree of sophistication requiring a subsequent level of management which cannot be realized in practice, leads to inefficient and unequal distribution of water. Salinity problems and problems with on-farm water distribution are to be mentioned as well. Of a more fundamental nature are the problems related to the integration of irrigated agriculture with the traditional agriculture farming system, based on rainfed, receding floods and livestock activities. Cultural practices on the major irrigated crop, rice, compete with these activities particularly during the beginning of the rainy season.

137) Due to the problems encountered in the management of the large systems, considerations are given to the possibilities of dividing the larger perimetres into smaller units, which are operated and maintained by the farmers, or farmers' associations. The same observations were made in the Philippines.

Physical and Operational Inadequacies in Canal Systems
(as cited by Indian officials)

References *
(see end of table)
Numbers refer to
respective page
number

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|-----|--|---|
| A. | MAIN SYSTEM INADEQUACIES | |
| 1. | Faulty original design | |
| 1.1 | The present level of competence in planning and preparing projects is too low. | CBIP 8, 41, 44
SHA 14
GVKR 15, 17 |
| 1.2 | The system most often lacks sufficient control structures or control structures are not properly designed. | CBIP 9
SHA 78
GVKR 17 |
| 1.3 | Canals are often of inadequate capacity in relation to peak demand. | CBIP 43 |
| 1.4 | Discharge capacity of project outlets (chaks) often too low in relation to the irrigation stream that can be handled by farmers. | CBIP 43, 47 |
| 2. | Faulty operation and maintenance | |
| 2.1 | Canal capacity less than original design capacity owing poor maintenance. | CGIP 7 |
| 2.2 | System operation often based on water availability rather than water demand. | CBIP 40 |
| 2.3 | Head-end farmers get oversupply of water in initial years and resist later reduction of supply. | CBIP 19
SHA 15 |
| 3. | Faulty modernization procedures | |
| 3.1 | Measuring devices often lacking | CBIP 7 |
| 3.2 | Phasing often unsuitable, e.g. overlooking that first effort should be to restore system back to original design capacity. | SMC Resolution No.3 |

3.3	Techniques for introduction of warabandi (rotational water supply) often not properly thought through or implemented. ¹	CBIP 12, 43, 47 SHA 15, 47 GVKR 16
3.4	Irrigation Dept. staff lack an adequate manual to guide them in diagnosis as a step in planning system modernization.	CBIP 2, 7, 8
B.	ON-FARM SYSTEM INADEQUACIES	
1.	Faulty institutional arrangements	
1.1	Lack of coordination among key agencies especially the Irrigation Dept., the Command Area Development Authority (CADA) and the Agriculture Dept.	CPIB 28 SHA 35
1.2	Failure to appoint a head to direct (rather than merely coordinate).	CBIP 44 ²
1.3	Lack of follow-through on Central Government recommendation to create separate Operation & Maintenance Wing in the State Irrigation Depts. ³	SMC Resolution No.3 CBIP 48
1.4	CADAs have inadequate administrative powers.	CBIP 48
2.	Faulty personnel policies	
2.1	Executive officers rotate too frequently.	CBIP 5
2.2	CADA administrators often too junior or fail to have leadership qualities.	GVKR 19 CBIP 27
2.3	The CADAs do not provide adequate career opportunities. ⁴	SHA 42

¹ The point is also made that, unless and until the main system is improved so that supplies are reliable and dependable as to quantity and timing, it is useless to try to introduce warabandi (SHA 47).

² In this reference it is recommended that a single person should direct all activities not only below the project outlet but above as well.

³ In CBIP 3 and 11 and GVKR 13 and 17 it is mentioned that pressure from international funding agencies has been highly instrumental in focusing attention on this problem and on the urgency for introduction of warabandi.

⁴ The Study Team was told that administrators are usually generalists from the Indian Administrative Service without previous background in irrigation or agriculture. Such administrators are often resented by engineers and agriculturists of the Irrigation and Agriculture Depts.

- | | | |
|-----|--|--------------------------------|
| 3. | Faulty manpower planning | |
| 3.1 | Lack of facilities for in-service training in water management. | CBIP 26
SMC Resolution No.6 |
| 3.2 | Lack of adequate curricula on water management in agricultural and engineering universities. | GVKR 19
SHA 50 |
| 4. | Faulty management practices | |
| 4.1 | Executive officers overloaded with administrative tasks. | CBIP 8 |
| 4.2 | Inadequate exchange within the country of lessons from experience reoperation of water users' cooperatives. | CBIP 2, 49 |
| 4.4 | Lack of clear targets for guidance of managers. ¹ | CBIP 29 |
| C. | FAULTY ON-FARM PRACTICES | |
| 1. | Plot-to-plot irrigation as widely practiced is inefficient. | CBIP 9, 38 |
| 2. | Known technologies of efficient water use are not being applied. ² | CBIP 8 |
| 3. | The States are slow in responding to Central Government's request to extend field channels at State expense to 5 to 8 ha blocks (rather than about 40 ha as at present). | CBIP 9 |

¹ In the Study Team's opinion, targets should be in terms such as value of agricultural production per ha or per m³ of water not merely in terms of 'irrigation area commanded' or 'field channels constructed' as at present.

² Where plot-to-plot irrigation is not practiced, the only other method is flood irrigation, also inefficient. Borders or furrows seem hardly to be used in India.

D and E FAULTY DRAINAGE AND ROAD SYSTEMS

1. Drainage system often omitted or inadequately designed. GVKR 11
SHA 14
2. Farm-to-market roads often lacking. SHA 18
3. Conjunctive use not sufficiently considered as means of reducing water-logging and salinity while supplying supplementary irrigation water. GVKR 11

G. FAULTY FARMING SYSTEMS

Research is lacking (and therefore farmers are not receiving advice) on appropriate farming systems including choice of cropping pattern either under existing conditions (with deficiencies in the water system) or under improved conditions. CGIP 2, 5, 21, 26
GVKR 17, 20

* CBIP = Central Board of Irrigation and Power: 'Warabandi for Irrigated Agriculture in India', Pub. No. 146, Nov. 1980.

GVKR = G.V.K. Rao, Member, Planning Commission: 'Irrigation Development in India - Tasks for the Future', Indian Agricultural Research Institute, Feb. 1980.

SHA = Syed Hashim Ali, IAS, 'Problems of Water Management and Command Area Development' Collected papers, 1980.

SMC = State Ministers Conference, Minutes, Sept. 1981.

ANNEX 4
A NOTE ON ACTION RESEARCH

The purpose of this note is to clarify what the Study Team means by action research.

The Study Team has had a lot of difficulty seeking a suitable term to describe the type of research activity which it recommends should have priority. It is similar to pilot projects but differs from them in having a stronger research and monitoring element. The term R and D has connotations of hardware technology which are misleading. 'Research' by itself is too passive and does not necessarily involve an active intervention. 'Action research' has the advantage that its two words emphasize the two parts of the activity: action - an intervention designed to improve and find out more about a system; and research - objective investigation and monitoring.

By way of illustration, two examples of effective action research already pioneered are:

1. IRRI's work in The Philippines. Initially this tested rotations at the tertiary level. When this did not lead to significant improvements, main system management was identified as the primary problem and became the focus. Interventions included improved communications with farmers, more sparing issues of water at the head, rotations, and minor improvements to structures, with careful monitoring and measurement of effects.
2. Colorado State University work in Pakistan. This concentrated below the mogha (outlet). Research identified high transmission losses in field channels, and action research then tested different improvements to reduce losses, leading to continuing replication of successes.

Some other action research, in progress or proposed, is listed in the appendix to this note.

Many methodological difficulties have been identified in action research, not least the problems of special treatment and of multiple causation. Nevertheless, rapid progress is being made in learning about and overcoming these problems. The number of action research projects, starting somewhat in isolation, is increasing. New ideas about methodology are being generated, through experience and through the interaction of the approaches of different disciplines. The next few months and years will be a formative period. A high priority is mutual exchanges between action researchers, the development and testing of cost-effective methods, and then their diffusion.

The action research, as currently understood, typically involves six activities:

1. multi-disciplinary diagnostic analysis of an existing irrigation system and the choice of action interventions;

2. benchmark surveys;
3. action taking;
4. monitoring and evaluation;
5. learning lessons from the experience;
6. extending and diffusing those lessons.

The institutional and physical forms of action research will vary widely. At this stage it is not desirable to define them too tightly. Eclectic approaches, involving researchers, irrigation staff, and farmers, and variously using modelling, rapid appraisals, different data sources, and different combinations of disciplines and of interventions, will be best. One institutional form is to combine an action team - those who manage an irrigation system, and a research team - a group from another institution which is responsible for research and monitoring. The experimental treatments can vary widely. Geographically they can involve a whole canal system, or part of it, or just the area below one outlet. Institutionally, they can, for example, involve changed distribution of water on the main system, methods of communication between farmers and irrigation staff, farmer organizations, methods of monitoring and evaluation, and so on.

Physically, they can, for example, include rehabilitation, new control structures, changes in the design and location of outlets, and/or on-farm development. Truly multi-disciplinary diagnostic analysis will identify action research interventions which will differ system by system.

Action research is not the only point of entry for improving irrigation management, but it is a potentially powerful multi-purpose tool. As a precondition, it needs good methods of appraisal, diagnosis and prescription. Once it is well under way, it can serve as a learning and training laboratory for irrigation management staff, agricultural staff, researchers, and others. The data generated may be used, as has been done on the Gal Oya Project in Sri Lanka, to create irrigation simulation games with immediate application in professional training and in on-going programmes. Its findings should feed back into improved management on a wider scale, and into planning and design. Above all, it has the great virtue of engagement with field realities, so that the outcomes should be of immediate practical use.

APPENDIX

Some Examples of Action Research

This list illustrates the range of action research broadly interpreted. For the purpose of this note it includes interventions on irrigation systems where there is a systematic attempt to monitor and/or evaluate the effects of the intervention. This includes cases where an irrigation agency monitors its own performance. The list is not a complete one.

Country	Project	Main Interventions	Agencies Involved	Status of AR
Bangladesh	Ganges-Kobadak Project	not known	ERRI Water Dev. Board IRRI	negotiating
Egypt	Egypt Water Use and Management Project (3 sites)	lining, raising water courses, field levelling, reducing field size, scheduling/night irrigation, etc.	Water Research Centre Colorado State University	continuing
India	Mahanadi Reservoir Project Hasdeo Bango Proj.	8 ha outlets and rotation between them	Water and Power Consultancy Services, Delhi Madhya Pradesh Irrigation Dept.	completed
India	General 'Centrally Sponsored Soil & Water Management Pilot Projects'	On-farm development works Rotational Water Supply	All CAD Authorities Central Government financing for 3 years (monitored by pilot project staff)	completed

Country	Project	Main Interventions	Agencies Involved	Status of AR
India	Hissar	Monitoring the performance of large scale irrigation projects (warabandi 70,000 acres)	Haryana Irr. Dept. Indian Inst. of Agr. Statistics	To be finished June 1982
India	Sukhomajri	Construction and operation of small village level irrigation systems	Central Soil & Water Conservation Research & Training	replication
India	Nagarjunasagar Right Bank, CADA Andhra Pradesh	management of a branch canal	Water Technology Centre, Delhi (FF) Nagarjunasagar RB, CADA A.P. Irrigation Dept.	continuing
India	Lower Bhavani, Tamil Nadu	Redistribution of water Lower water issues Eliminating waterless seasons	Tamil Nadu Agricultural Univ. Irrigation Dept., Tamil Nadu Indian Council for Agric. Res.	continuing
India	Tanks, Tamil Nadu	Alternative irrigation management	Perarignar Anna University of Technology, Madras (FF)	continuing
India	Jayakwadi, Maharashtra	Rotation of water supply within chak and on-farm development	Jayakwadi CADA, Maharashtra	continuing

Country	Project	Main Interventions	Agencies Involved	Status of AR
India	Mahanadi (delta) Orissa	Rehabilitation and management of water distribution on a distributary and at farm level	Orissa Irrigation Dept., Orissa Agri. Dept., World Bank consultant (Wickham)	continuing
India	Sreeramasagar (Pochampad), Andhra Pradesh	Warabandi management of distributaries and main system, Farmers' orgs.	Sreeramasagar CADA Andhra Pradesh Irrigation Dept. World Bank, FAO Investment Centre	continuing
India	Nagarjunasagar Right Bank Tunghabadra	Rehabilitation above the outlet combined with redistribution of water through rotations to benefit tailenders in particular	Respective Command Area Development Authorities Andhra Pradesh Irrigation Dept. (All monitored by CADA)	continuing
India	Upper Ganga	Not yet known	Water Resources Devt. Training Centre, Roorkee UP Irrigation Dept. (FF)	funded
India	Kangsabati West Bengal	Not yet known	Indian Institute of Technology, Kharagpur. Kangsabati Command Area Dev. Authority (FF)	funded
India	Mahi-Kadana, Gujarat	To be determined	Central Water Commission Gujarat Irrig. Dept. (FF)	awaiting government clearance

Country	Project	Main Interventions	Agencies Involved	Status of AR
India	Tawa, Madhya Pradesh	To be determined " "	Central Water Commission MP Irrig. Dept. (FF)	awaiting government clearance
India	Tanks (West Central India)	Not yet known	IIM - Ahmedabad (FF)	awaiting government clearance
India	Sarda-Sahayak, Uttar Pradesh	Not yet known	Planning, Action and Research Division, State Planning Inst. Sarda Sahayak Command Area Dev. Authority (FF)	awaiting government clearance
Indonesia	Sederhana Programme	Not known	Ministry of Ag. Indonesia IRRI	negotiating
Indonesia	Several projects	Details not known	(FF)	
Pakistan	Mona Reclamation Experiment Proj.	Below the mogha	Colorado State University (USAID)	completed
Pakistan	Mona Reclamation Experiment Proj.	Below the mogha	WAPDA	continuing

Country	Project	Main Interventions	Agencies Involved	Status of AR
Pakistan	Shahkot - field site of the WM Res. and Trg. Project for Rural Dev., Univ. of Ag., Faisalabad	Physical changes below the mogha Farmers' organizations	Univ. of Ag., Faisalabad	continuing
Philippines	On-farm facilities study	Different levels/types of facilities	NIA IRRI	1981 is last year of 4 year project
Philippines	Communals Irrigation	Farmers participation, structures, management	NIA AIM (FF) IRRI	continuing replicating
Philippines	Pest control through synchronous cultivation	Synchronous water supply and cultivation activities	NIA IRRI	first major test 1982
Philippines	Irrigation System Management	3 levels of intensity of staffing etc.	NIA IRRI	1981 first year Undertaking benchmark
Philippines	Pump system in Bicol Region	Attempting optimal management	NIA IRRI	Intervention started 1981 continuing

Country	Project	Main Interventions	Agencies Involved	Status of AR
Philippines	Farmer organization above the outlet at the lateral level	Farmer organization	NIA IRRI	not known
Sri Lanka	Five tanks	Structural, institutional, cropping pattern, and water supply delivery	World Bank ODA Dept. of Irrigation	Several years' experience
Sri Lanka	Gal Oya	Farmer participation	Agrarian Research and Training Institute Cornell University (USAID)	continuing

(FF) indicates Ford Foundation funding

(USAID) indicates USAID funding